THE DENTAL PRACTITIONER

AND DENTAL RECORD

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THE DENTAL PRACTITIONER

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Lewis, R. W. B. (1947), *The Jaws and Teeth*, 2nd ed., 471. London: Science Publishing Co.

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THE DENTAL PRACTITIONER AND DENTAL RECORD

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EDITORIAL

PLANNING THE SURGERY

THE study of time and motion would seem to be a project which could be carried out by most practising dentists to advantage. In every practice there occurs an occasional attempt to streamline the duties and procedures of each member of the staff as well as to simplify the operator's techniques. However, much of this comes to naught because of poor surgery planning and unsatisfactory equipment design.

Most dental surgeries, like Topsy, just grow. The newly qualified practitioner buys a chair, a unit, a cabinet, a sterilizer, and an X-ray machine along with a few further accessories. He has made his choice with the help of the representatives of the dental supply houses and possibly his knowledge of one or two surgeries. This equipment is placed—as it fits—around a room which was not designed for its present purpose. When something else is required it is added—by which time the dentist usually realizes that he has made several errors of judgement too expensive to correct, even if the ideal items of equipment are available on the market.

This, however, is often not so. Dental manufacturers, though yearly improving their designs, are still apt to base improvements on the original concept of the equipment in question. The dental unit is a case in point. Just prior to the recent revolutionary and highly simplified standard, most units were reminiscent of a lavishly decorated Christmas tree. As a new gadget came on the market, so the manufacturer added it to his current dental unit. Even to-day the simplified standard is still designed for placing in the traditional position: in combination with the spittoon, on the left of the chair, necessitating that the operator works across the patient. Is it not time that we considered a dental unit to place on the same side as the operator?

The Council of Industrial Design recently pointed out some of these problems and has attempted to produce a perfect functional surgery plan in their magazine, *Design*—not, unfortunately, altogether successfully. It is obvious that a considerable amount of time-and-motion study and expert planning is still necessary. So far, first principles (i.e., the basic needs of the people using the surgery) do not appear to have been foremost in the minds of designers.

Is it not perhaps the precise moment for expert planners from industry to consider the problem for us—from a fresh viewpoint—and if necessary to create a completely new concept for surgery layout and design?

THE CLASS II CAVITY PREPARATION FOR PRIMARY TEETH AND ITS RESTORATION WITH SILVER AMALGAM*

By **RALPH L. IRELAND,** D.D.S., M.S.
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THERE are many factors which may affect the quality and life of a silver amalgam restoration. These factors can probably be placed in three major groups:—

1. The shape of the cavity preparation,
2. The skill of the dentist in the manipulation of the restoration material, and
3. The mechanical properties of the material.

This discussion will be confined to presenting a concept of cavity form which in some respects is directly opposite to that which is taught and practised generally by dentists. The Class II cavity preparation to be discussed embodies the principle of rounded angles and a rounded pulpal wall instead of the conventional preparation with sharp angles and a flat pulpal wall.

REVIEW OF THE LITERATURE

A review of the literature reveals that rounded angles in cavity preparations are not revolutionary. Sturdevant (1938) suggested rounding the base angles in cavities prepared for inlay restorations. Sturdevant stated: "The principle involved is not new. As a matter of fact, it has been employed in the industry of pattern-making for many years. The application of this principle to dentistry was first suggested to me by Bert L. Hooper, who has given me valuable assistance in preparing this work." The teaching of G. V. Black, however, was so firmly fixed in the minds of dentists that little if any attention was given to the suggestion of Hooper and Sturdevant. Sharp angles in cavity preparations have continued to be the order of the day.

A scientific study of the problem of cavity form was reported by Noonan (1949). Noonan made use of photo-elasticity in his study of the internal stresses created in the tooth as a result of different cavity shapes. The conclusions reached by Noonan were:—

1. A flat floor permits less stress concentration than one which is rounded. In the flat based restoration studies, the maximum stress is approximately 20 per cent greater at the corners than at other points on the base. To be of a serious nature the maximum would have to be from 50 to 100 per cent greater;
2. A rounded angle permits less stress concentration than a sharp angle; and
3. Retention points should not be sharp but rounded to decrease stress concentration.

Lampshire (1950) completed a study designed to test and evaluate the various Class II cavity forms and mechanical principles which had been suggested by various writers and teachers in order to determine which principles, or combination of principles, would be the most beneficial to include in such a cavity prepared for a silver amalgam restoration. The following principles and variations in form were tested: a narrow and a wide occlusal isthmus; a square and a round pulpo-axial line angle; a flat and a rounded pulpal wall; retention groove placed in the gingival wall, and buccoaxial and linguoaxial retention grooves placed in the proximal box. An analysis of each principle tested showed that the wide occlusal isthmus, the rounded pulpal wall, and the buccoaxial and linguoaxial side grooves in the proximal box provided the greatest increase in the resistance of the silver amalgam restoration to fracture. Rounding the pulpoaxial line angle increased the resistance to fracture only slightly, while the addition of the gingival retention groove was of little benefit. It was also shown that when the cavity preparation with a narrow occlusal isthmus, a flat pulpal wall, and a sharp pulpoaxial line angle was compared to the cavity preparation with a

* Paper presented at the annual meeting of the American Dental Society of Europe, held on July 5–8, 1960, in Edinburgh.

wide occlusal isthmus, a rounded pulpal wall, buccoaxial and linguoaxial retention grooves, and rounded pulpoaxial line angle, there was, in the case of the latter, a tremendous increase in the resistance of the silver amalgam restoration to fracture.

Two photo-elastic studies designed to determine the effect various cavity designs have on

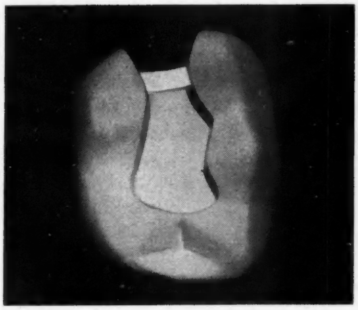

Fig. 1.—Outline form of occlusal step in Class II cavity preparation.

the stress pattern variations in the restoration were completed recently by Haskins (1954) and Guard (1954). Haskins studied the stress distribution in mesiodistal sections of the Class II cavity restorations, while Guard's study was concerned with buccolingual sections.

The results of these studies showed that if certain mechanical principles were incorporated in the Class II cavity preparation, they could alter significantly the resistance of the silver amalgam restoration to fracture and affect the stress pattern produced in the restoration. The cavity preparation with the gently rounded pulpal wall and gently rounded angles showed the lowest maximum fringe order around the boundary of the model as well as the best conformity to the boundary. These studies also showed that when many of these principles were incorporated in the same cavity design, the silver amalgam restoration reached its greatest efficiency in resisting fracture.

As a result of these and other studies, and the 1951 report of the American Academy of Pedodontics Committee, the following principles may be recommended for the Class II cavity preparation for the primary teeth:—

OUTLINE, RESISTANCE, AND RETENTION FORM

1. The Occlusal Step (*Fig.* 1).—

a. The occlusal step should be dovetail in shape. The outline of the occlusal step should be composed of arcs of circles and gently rounded curves. The outline form should include all sharp retentive occlusal fissures,

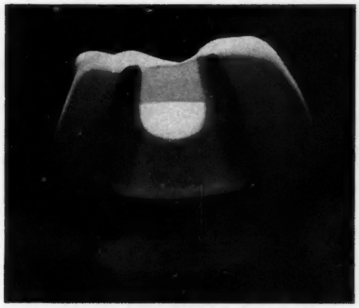

Fig. 2.—Outline form of proximal box portion in Class II cavity preparation. Note the gently rounded pulpal wall, the rounded angle formed by the side walls of the occlusal step and the pulpal wall, and the rounded buccogingival and linguogingival line angles.

pits, developmental grooves, and all carious areas.

The distance the occlusal step is extended mesially or distally varies with the morphology and occlusal surface anatomy of the particular primary molar concerned.

b. The cavo surface margins should not be in stress-bearing areas. No cavo surface bevel should be placed.

c. The side walls of the occlusal step should be parallel, or they should converge slightly as they approach the cavo surface margin.

d. The angle formed by the side walls of the occlusal step and the pulpal wall should be gently rounded.

e. The pulpal wall should be gently rounded.

f. The pulpal axial line angle should be gently rounded.

2. The Proximal Box (*Fig.* 2).—

a. The buccal and lingual walls of the proximal box should flare sufficiently so that the proximobuccal and proximolingual cavo

surface margins are in self-cleansing areas. A 90° cavo surface angle is desirable.

b. The depth of the proximal box should be such that a substantial gingival wall may be established, all carious areas removed, so that the proximogingival cavo surface margin may be established under the free margin of the gingival tissue.

c. The flare to the buccal and lingual, respectively, of the buccal and lingual walls should be kept to a minimum consistent with extension into the relative immune embrasures. A 90° cavity surface angle is desirable.

d. The buccal and lingual walls of the proximal box should converge slightly from gingival to occlusal with the greatest buccolingual width in the gingival area.

e. The buccogingival and linguogingival line angles should be gently rounded.

f. Buccal axial and lingual axial retention grooves may be placed from the gingival wall occlusally to the dentinal–enamel junction. The side grooves should be round.

RUBBER DAM APPLICATION

The dentist who uses the rubber dam will find that the advantages of its use far outweigh the disadvantages. The use of the rubber dam will enable the dentist to:—

1. Increase his operating speed and efficiency.

2. Improve the quality of his operative dentistry (cavity preparation and silver amalgam restorations).

3. Reduce his child management problems.

Equipment required: Rubber dam punch, rubber dam forceps, rubber dam clamps (S.S. White 26 and 24), Young's rubber dam frame, rubber dam (dark) 5×5-in. pieces.

Procedure for placing rubber dam:—

1. Place rubber dam over Young's rubber dam frame.

2. Punch holes in rubber dam. (Hole No. 3 for maxillary or mandibular second primary molars; hole No. 2 for maxillary or mandibular first primary molars.)

a. Divide dam into four quadrants; for the maxillary right second primary molar, the hole is punched in the upper left quadrant approximately ½ in. up and to the left of the centre of the dam. (Turn dam over for use on maxillary left side.)

b. For the mandibular right second primary molar, punch hole approximately ½ in. to the left of the centre of the dam. (Turn dam over for use on mandibular left side.)

3. Place rubber dam clamp on tooth. (Clamp 26 is used for the primary second molars and clamp 24 is used for the primary first molars.)

4. Lubricate rubber dam around punched holes.

5. Place dam over distal extension of the clamp. When placing dam on mandibular teeth, stand in front of patient. When placing dam on maxillary teeth, stand to the side and back of the patient.

6. Stretch dam laterally and pull forward to place dam under the buccal and lingual flanges of the clamp.

7. If both primary molars and cuspid are to be isolated stretch punched hole over these teeth.

8. A ligature may be used to work the dam between tight contacts. A blunt-ended instrument, such as a beaver-tail burnisher, is useful to adapt the dam under the gingival tissue.

9. When more than two teeth are to be isolated, a small piece of dam, single or double thickness, placed between the primary cuspid and lateral incisor will help to hold the dam in place.

CONSTRUCTING AND ADAPTING THE MATRIX BAND

It is essential that a matrix band be used when compound cavities in the primary or permanent teeth are filled with silver amalgam in order to insert a properly condensed and contoured silver amalgam restoration.

The short occlusocervical and incisocervical length of the crowns, the prominent buccocervical ridge on the molars, the marked constriction of the crown in the cervical area, and the converging buccal and lingual surfaces of the molars as they approach the occlusal surface, make the job of constructing a matrix band for the primary teeth a difficult one. After thoroughly investigating and experimenting with various types of matrix band and retainers, it was concluded that an individual

type band, tailor-made for each tooth, came the closest to meeting our requirements and was the most satisfactory for our use.

This "all-purpose" matrix band has in every way lived up to our expectation. The matrix band should be constructed of a material which can be spot welded or soldered with lead solder (stainless steel band material cannot be soldered with lead solder).

TECHNIQUE OF CONSTRUCTING MATRIX BAND

1. A strip of band material, approximately 0·18 in. (0·45 cm.) wide, is cut and placed around the tooth. With the thumb or index finger holding the band material on the lingual surface of the tooth, the two ends are pulled together on the buccal aspect of the tooth with flat-nose pliers or orthodontic band-forming pliers. If desired, the two ends of the band material may be pulled together on the lingual side of the maxillary molars.
2. The band is removed, the two right-angle bends are brought together and are either soldered with lead solder or spot welded.
3. After the band is removed from the tooth, and the joint is to be soldered, the two right-angle bends are held together by orthodontic soldering pliers. Any portion of the band material that extends more than 0·25 in. (0·64 cm.) beyond the right-angle bend is removed.
4. A small amount of lead solder flux is applied to the inside of the band where the right-angle bends are joined and the seam is soldered with lead solder. If lead solder is not available, the lead foil backing on X-ray films may be used. Only a small amount of solder is necessary and the heat from an alcohol lamp is preferable to that of a bunsen burner or orthodontic blowpipe. If too much solder has been used, it may be scraped away, just before it solidifies, with a beaver-tail burnisher or an instrument of similar shape.
5. Remove the excess band material on the outside of the solder joint. Place the band on the tooth. The band should fit the tooth tightly, should not extend too far beyond the marginal ridge of the adjacent tooth or the contemplated height of the marginal ridge of the restoration, and should not damage the gingival tissue. After the band has been trimmed and contoured, cavity varnish may be painted on the inside and outside of the solder joint to prevent the mercury in the silver amalgam from contacting the lead solder and opening the soldered joint.
6. Place the matrix band on the tooth and insert a gingival wedge.
7. Place the flat side of a beaver-tail burnisher in the proximal portion of the cavity and recontour the mesial and/or distal side of the band.
8. When it is time to remove the matrix band, the operator may pry the solder joint apart with a spoon excavator, or cut the band with a knife-edge stone or crown scissors.

THE GINGIVAL WEDGE

A wedge, inserted at the gingival aspect, will prevent an overhang of silver amalgam. Any wedge which the operator is accustomed to using may be employed.

TRITURATION

Trituration may be accomplished satisfactorily with either a hand technique or with a mechanical amalgamator. Regardless of which method is used it is important to remember that research studies have shown that the time and degree of trituration are important and that it is better to "over" triturate than "under" triturate (Roper, 1947; Sweeney, 1940; and Miller, 1947). More consistent results, no doubt, can be produced by using a mechanical amalgamator. Another advantage in using a mechanical amalgamator is that its speed permits multiple mixes to be made, and assures that the operator always uses a fresh mix of amalgam when large cavities have to be restored. Sweeney (1944a) called this method the "instalment plan" of mixing and packing. He pointed out that this method provides the operator with amalgam which at no time "exceeds the age of three minutes".

Freshly mixed amalgam gives up excess mercury more readily than when it has been allowed to stand three to five minutes. Ward and Scott (1932) showed that amalgam which

was allowed to remain on the bracket table for five or more minutes contained more mercury than amalgam which was packed immediately after mixing.

Excessive expansion of amalgam is due to moisture contamination. It is essential that moisture does not come in contact with the amalgam during the mixing or packing operation.

CONDENSING AND CARVING SILVER AMALGAM

According to Black (1947) and Sweeney (1944b) the size of condensing points governs the packing pressure applied to a unit area and should, therefore, fill as much of the cavity space as possible. Small condensing points only "punch" through the amalgam and there is little if any condensing pressure applied. The type of force rather than the amount of force is also an important consideration when condensing amalgam into the cavity. A "rocking" or "vibrating" force is considered best for eliminating excess mercury.

Carving the silver amalgam restoration to contour may be done with sharp instruments. Only those surfaces which can be polished later should be touched with carving instruments. Carving, therefore, is confined to the occlusal surface and the buccal and lingual margins of the proximal box. If there is an excess of silver amalgam it should not be removed until later when the restoration is polished.

FINISHING AND POLISHING THE RESTORATION

If the silver amalgam has been properly condensed and the restoration carved to the required contour, the finishing and polishing can be accomplished in a short period of time. Finishing and polishing is done approximately one week after the restoration is placed. Sharp large round and fissure burs and stones may be used to remove high spots and any excess amalgam covering enamel margins. If there is excessive amalgam at the gingival margin it may be removed with gold files.

A mixture of pumice and water flavoured with a drop of oil of wintergreen is used on a stiff bristle prophylaxis brush to remove scratches. Tin oxide, or whiting mixed with water to a thick paste, is applied with a brush for the final polish.

SUMMARY

1. Research has shown that if certain mechanical principles are incorporated in the Class II cavity preparation they can alter the resistance of the silver amalgam to fracture and affect the stress pattern produced.

2. The following principles were found to be desirable to include in the Class II cavity preparation for silver amalgam restorations: A wide occlusal isthmus, rounded line and point angles, a rounded pulpal wall, a rounded pulpal axial line angle, buccoaxial and linguo-axial retention grooves in the proximal box.

3. Suggestions for placing the rubber dam, constructing the matrix band, preparing and condensing silver amalgam, and for carving and polishing silver amalgam restorations were made.

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— — (1944b), *Ibid.*, **31**, 379.

Illustration of Fossil Vertebrates

A discussion and description of various methods of making illustrations of fossil remains are given. The paper is particularly valuable to those interested in recording comparative dental anatomy, as is shown by the pictures contained therein.—Colbert, E. H., and Tarka C. (1960), *Med. biol. Ill.*, **10**, 237.

Donald D. Derrick

THE EPITHELIA IN THE DENTO-GINGIVAL JUNCTION*

By **W. S. ALLDRITT**, M.D.S., F.D.S.
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THE eruption of a tooth into the oral cavity may appear to interrupt the continuity of the mucous membrane. Clinical observation indicates, however, that a mechanism has evolved which can maintain functional continuity throughout the patient's life, assuming effective hygiene is practised.

It is necessary to study the tooth and its investing structures at a microscopic level to determine the details of this mechanism. The mucous membrane consists of two layers, an epithelium of the stratified squamous type and a connective tissue corium. The method of attachment of connective tissue to the tooth has been studied by Goldman (1951) and others, and here there is general agreement. It is now accepted that collagen fibres extend from the margin of the alveolar bone and that portion of root surface which projects beyond the bone margin, through the body of the gum, to end in the papillary layer of the corium. These fibres run fan-wise from tooth and bone into the mucosa and can be traced to the gum margin in one direction and over the bone crest in the other. They are supported by other fibres which run horizontally around and between the teeth (Goldman, 1959). This arrangement of fibres results in a firm attachment between corium and tooth. Consequently the characteristics of the mucosa are altered so that it becomes identifiable as gum tissue.

The relationship between oral epithelium and tooth has also been investigated by various authors, but the problems encountered are more complex than those relating to the connective tissue attachment. For this reason universal agreement has yet to be achieved. The relationship between tooth and epithelium cannot be established by examination of demineralized histological preparations. Histological techniques of this type not only remove the enamel completely, but can only provide a static picture of the region with little or no indication of its functional activity.

The history of the problem may be considered as having three periods. Prior to 1920 it was generally believed that the gingival epithelium extended from the gingival margin along the enamel to the cement-enamel junction (Black, 1915). In describing this replication of the oral epithelium no mention was made of an attachment to the tooth surface. This is not surprising, as demineralized tissue sections were studied, which, in themselves, did not suggest that union had previously existed. Consequently the gingival sulcus was assumed to extend from the gingival margin to the apical end of the epithelial replication. This point corresponded on the tooth with the cement-enamel junction, or as Black termed it the gingival line. Apparently a potential space was envisaged between enamel and the epithelium and it was suggested that exudation of tissue fluid might occur from this area.

The second period started around 1920, when Gottlieb suggested a different relationship between enamel and epithelium. This relationship was part of a comprehensive theory which attempted to correlate certain pre-eruptive changes in the enamel organ with the depth of sulcus around the erupted tooth. In this theory the concepts of passive eruption and continuous physiological eruption were introduced. One observation made by Gottlieb was that the epithelium in contact with the enamel following eruption was derived from the enamel organ and not from the gingival epithelium. He differed from Black not only in the origin of the epithelium, but also in maintaining that it was in organic union with the enamel surface, this union being a persistence of that which exists during tooth formation. This hypothesis was presented with the force of an experimental observation, and it was therefore logical to contend that the gingival sulcus should be of minimal depth. The remnant of the enamel

* Based on a paper read to the British Society of Periodontology, May, 1959.

organ united to the enamel was termed the epithelial attachment.

These observations and opinions gained acceptance by many histologists and apparently received support from investigations reported subsequently in the literature. As is so often the case, however, these reports were capable of more than one interpretation. They will be referred to later in the paper.

It was not until 1952 that doubt was cast on the organic union between epithelial attachment and tooth. In 1952 Waerhaug published the results of experiments which had been carried out on dogs. His experiments can be divided into two basic types. One type investigated the relationship between various materials, including enamel, metal ligatures and acrylic, and the healthy epithelial attachment (Waerhaug, 1952, 1957, 1958). The other type investigated the healing power of the epithelial attachment (Waerhaug, 1952, 1955a, b). It is realized that these two aspects are closely inter-related, but it may help to clarify the results obtained by this investigator and counter misconceptions regarding his work if these two categories are considered separately. The experiments on the healing power of the epithelial attachment indicated that when the union between epithelium and tooth is interrupted processes of repair and regeneration occurred comparable to those which occur elsewhere in the body. The epithelial attachment was observed to undergo regeneration histologically indistinguishable from a control. This work suggests that the manner in which epithelium and tooth are related does not depend upon cellular changes during the developmental period. Therefore the epithelial attachment does not rely on passive organic union for its integrity, a union which, once broken, cannot be re-formed, but rather on an active response to damage without permanent change.

Waerhaug's investigation of the relationship between epithelium and tooth did not substantiate the existence of an organic union between the two tissues. Instead, the epithelium adheres to the tooth surface, possibly by means of a cuticle, and in no way contributes to the attachment of gum to tooth. It would appear that the epithelial attachment should be envisaged as an epithelium interposed between gingival corium and tooth, and functioning as a bacterial barrier with only limited inherent resistance to retraction. For this reason Waerhaug's term "epithelial cuff" is more acceptable than "epithelial attachment". It is an anatomical term which does not introduce a hypothetical relationship.

Such conclusions were contrary to the generally accepted view, and obviously it was desirable that further work should be carried out to verify these findings. Orban, Bhatia, Kollar, and Wentz (1956) published the results of experiments similar to some of those carried out by Waerhaug, and concluded from these that a "true" epithelial attachment, i.e., an organic union, does exist. However, this paper did not attempt a complete appraisal of Waerhaug's work, and for this reason it does not appear to be an important contribution to the literature. These authors referred to investigations by Ussing (1955) and Toller (1940) as providing additional evidence for the epithelial attachment concept or, as they now term it, the "attached epithelial cuff". Care is required, however, when attempting to apply Ussing's observations to the post-eruptive period. Ussing observed that when the follicle is removed from the crown of an unerupted tooth, the bulk of the enamel epithelium remains on the enamel. Pre-eruptive changes in the connective tissue may predispose to cleavage between this tissue and the epithelium when the follicle is manually removed from the tooth, and therefore give an erroneous impression of the firmness of union between reduced enamel epithelium and crown. This possibility was recognized by Ussing. Baume (1952) has also discussed such autolytic changes prior to eruption. Also, Ussing's observation of fibrils apparently extending from the cuticle into the enamel is not evidence for an attachment mechanism; similar fibrils have been shown by Waerhaug in epithelium which has been adapted to restorative materials.

Toller's work, which attempted to investigate the presence and strength of an epithelial attachment by retracting gingiva by means of

threads, does not make allowance for the effect of the gingival fibres in determining the pattern of detachment.

Waerhaug's work provides a rational basis for an understanding of gingival physiology and pathology which the essentially passive concept held prior to his work failed to provide. The dogmatic attitude adopted by Gottlieb and his associates had the effect of embalming this aspect of dental anatomy, a point brought out by Weinmann (1956) when he says that further research was apparently unnecessary as Gottlieb's elegant interpretations were taken for granted.

It should be remembered that Gottlieb formulated his theory on the basis of histological examination of demineralized tissue, unsubstantiated by any experimental evidence. Despite this, other workers were expected to accept his concepts and were strongly criticized when they appeared slow to appreciate the "great importance" of an epithelial attachment (Orban and Mueller, 1929). This aggressive policy must have played a part in inhibiting further research.

So far we have been considering the origin of the epithelial cuff and its relationship to enamel. The mode of union of external epithelium and epithelial cuff will now be considered. Following surgical removal of gum and epithelial cuff, regeneration occurs during which a new epithelial cuff is formed. This must originate from gingival epithelium, and under these circumstances cellular continuity between gingival epithelium and epithelial cuff would be expected. Waerhaug (1955b) has shown that this is so. However, the original cuff is derived from the enamel organ and must unite with oral epithelium at the time of eruption. In man and some animals, such as the dog, there does not appear to be any demarcation between gingival epithelium and epithelial cuff so that histologically it is not possible to decide where one epithelium stops and the other starts. In these animals the histological appearance of the healed tissue following gingivectomy is indistinguishable from that existing in the normal healthy state. If these epithelia are considered as comprising one continuous layer with the reflected portion attached to the tooth, as did Gottlieb, a problem arises when explaining how passive eruption occurs. Passive eruption is the process of exposure of the crown by apical shift of the gingival margin and is distinct from active eruption of the tooth towards occlusion. The process by which the gingival margin assumes its adult position appears to involve cellular activity to an extent which makes the term misleading. The term "gingival maturation" is therefore considered preferable when referring to the retreat of the gingival margin to the adult position.

This process must entail detachment of the epithelium from the crown, assuming an attachment exists, but how does such detachment occur if the oral epithelium is continuous with and indistinguishable from the epithelial attachment and this structure in turn is attached to the tooth? Gottlieb (1927) recognized this problem and attempted to explain detachment on the basis of death of the enamel surface. Another explanation which has been offered (Orban, 1944) is that detachment is due to a physiological involution process which is preceded by degeneration of the epithelial cells at the base of the gingival sulcus. This degeneration is considered to be caused by continuous bacterial and mechanical irritation. It is not clear why such a process fails to result in continued destruction of the epithelial attachment.

A third explanation was suggested by Becks (1929). As a result of an investigation of human and animal material he suggested that gingival epithelium unites with the epithelial attachment by growth of gingival epithelium in an apical direction along the connective tissue side of the epithelial attachment. The photomicrographs of human material in this paper appear to show marked inflammatory changes and therefore cannot be considered in an investigation of the normal. However, the animal material which appeared to be free of inflammatory changes suggested that in some animals the gingival epithelium is reflected from the gingival margin along the epithelial cuff separating it from the connective tissue. Becks considered that with increasing age the gingival epithelium eventually extended

to the cement-enamel junction, thereby covering the epithelial cuff. This paper was an important contribution in that it suggested a method by which gingival maturation might occur without introducing epithelial detachment. Skillen (1930) made similar

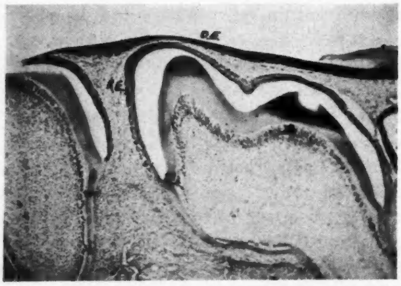

Fig. 1.—Mesiodistal section of second mandibular molar showing reduced enamel epithelium (R.E.) and oral epithelium (O.E.). 21 days. H. and E. (× 36.)

Fig. 2.—Further sectioning of the jaw shown in *Fig.* 1 reveals proliferation of oral epithelium and union with enamel epithelium over the mesial cusp. H. and E. (× 24.)

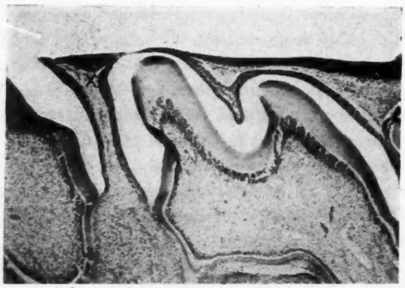

Fig. 3.—Mesial cusp of mandibular second molar about to erupt. Note oral epithelium at X proliferating over enamel epithelium. 23 days. H. and E. (× 36.)

Fig. 4.—Epithelial proliferation into connective tissue in occlusal fissure (X). 23 days. H. and E. (× 24.)

observations to those of Becks with respect to the rat. He considered that the gingival epithelium in this animal extends along the connective tissue surface of the epithelial cuff.

A preliminary review of animal material by Scott and Alldritt (1957) supported this concept with regard to rodents.

MATERIAL USED

Albino rats were sacrificed by decapitation following ether anæsthesia and fixation was obtained with cold acetone. Following dehydration, the sections were embedded in paraffin wax and sectioned at 7 μ. The stains used were hæmatoxylin and eosin, and Fullmer's stain for connective tissue (1958). The investigation was confined to the molar teeth of rats ranging in age from 21 days to adult.

OBSERVATIONS

Fig. 1 shows the crown of the second mandibular molar covered by reduced enamel epithelium. Union is about to be made with the basal layer of the oral epithelium. Further sectioning of this specimen (*Fig.* 2) reveals that union has already occurred between these epithelia over the mesial cusp as a result of proliferation of oral epithelium. Over the distal cusp a cap of oral epithelium is present, distinct from the superficial layer of oral epithelium. This appearance results from a union such as has occurred over the mesial

cusp followed by lateral proliferation over the reduced enamel epithelium.

In *Fig.* 3 the mesial cusp is just about to appear in the mouth. Following perforation of the oral epithelium as in *Fig.* 4, the connective tissue lying in the occlusal fissure is permeated by strands of proliferating epithelium.

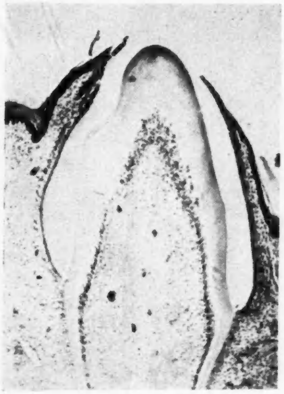

Fig. 5.—Buccolingual section near mesial surface of mandibular first molar. Eruption has just occurred. 21 days. H. and E. (× 30.)

Fig. 5 is a buccolingual section through the first mandibular molar, and gives a general survey of the tissues immediately following eruption. A higher magnification of the buccal gingiva at this stage of eruption (*Fig.* 6) shows the oral epithelium growing along the enamel organ epithelium. Due to the lack of pressure in this area the ameloblastic layer has persisted to the point where it is overlapped by the oral epithelium. In *Fig.* 7 is shown a buccolingual section illustrating the epithelial proliferation which occurs throughout connective tissue over the occlusal portion of the tooth. Such proliferation is presumed to take place as a result of various factors, such as the functional stresses from the antagonistic gum pad and

Fig. 7.—Buccolingual section of mandibular first molar. The connective tissue in the occlusal fissure is almost completely infiltrated by epithelium. 21 days. H. and E. (× 84.)

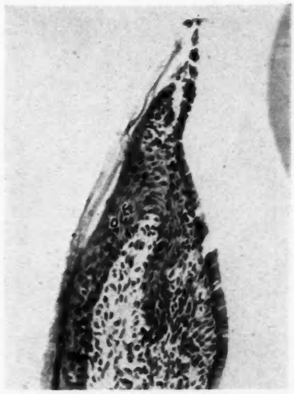

Fig. 6.—Higher magnification of buccal gingiva obtained from a section close to that shown in *Fig.* 5. Oral epithelium (O.E.) has grown down along the enamel epithelium to X. 21 days. H. and E. (× 150.)

Fig. 8.—Mesiodistal section showing distal surface of the mandibular second molar and the developing third molar. Gingival epithelium extends to X; note compression of the epithelia at Y. 25 days. H. and E. (× 48.)

autolytic changes in the connective tissue. There is a striking difference between the epithelial activity in the tissue over the occlusal surface and that occurring on the buccal and lingual sides.

Fig. 9.—Mesiodistal section through the mandibular second molar (2) and third molar (3). The interproximal tissue (I.T.) undergoes pressure atrophy as the crowns approximate. 29 days. H. and E. (× 60.)

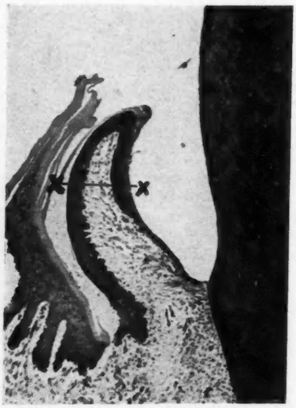

Fig. 11.—Buccolingual section of mandibular molar. The gingival epithelium has grown halfway along the epithelium derived from the enamel organ. The two epithelia are in close contact and there are no projections into the connective tissue corium. (For X–X *see Fig.* 12.) 46 days. H. and E. (× 60.)

In *Fig.* 8 the epithelium on the distal surface of the second mandibular molar is shown. It will be seen that the cells of the epithelial cuff show a degree of proliferation inversely proportional to the proximity of the crown to the bone and the developing third molar. The oral epithelium extends as far as point X. As

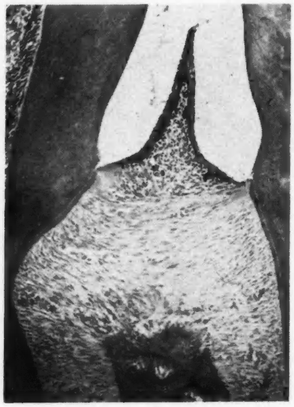

Fig. 10.—Mesiodistal section showing the united epithelial cuffs between mandibular first and second molars. Compare this picture with that shown in *Fig.* 1 to appreciate the rapidity of the tissue changes between 21st and 28th day. 29 days. H. and E. (× 48.)

eruption of the third molar progresses, the picture of the interproximal tissue undergoes rapid change.

Fig. 12.—Horizontal section through the buccal gingiva about the level of X–X in *Fig.* 11. Gingival epithelium, G.E. Epithelial cuff, E.C. 25 days. H. and E. (× 24.)

In *Fig.* 9 is shown a later stage in the eruption of the third molar in which the two epithelial cuffs are about to come into contact. The appearance of the interproximal papilla when the teeth have erupted into occlusion is

shown in *Fig.* 10. This appearance is found by the 29th day, and when compared with *Fig.* 1 it will be seen how rapidly the picture changes during the 4th week of life in the rat. *Fig.* 11 shows the typical appearance in a

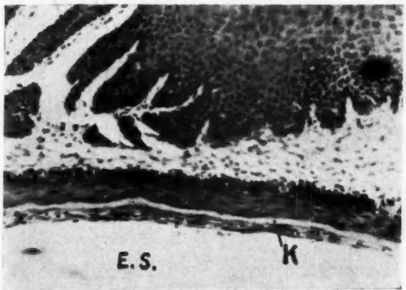

Fig. 13.—High magnification of area indicated in *Fig.* 12 showing keratin (K) between the gingival epithelium and epithelial cuff. Enamel space, E.S. (× 120.)

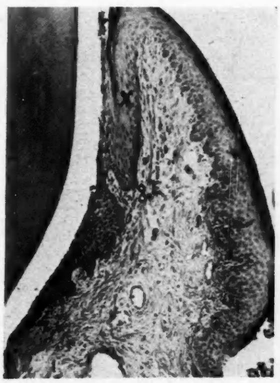

Fig. 14.—Mandibular buccolingual section. In this section the gingival epithelium is seen to extend into the connective tissue as a lamina (G.E.). The gingival keratin extends to X. 35 days. Fullmer. (× 75.)

mature animal. The gingival epithelium is reflected along the epithelial cuff for approximately half its length. The epithelia are closely adapted and present a uniform junction with the connective tissue. A horizontal section through the gingiva at the level indicated will give a picture similar to that shown in *Fig.* 12. Due to the lingual tilt of the molars necessary to obtain a true horizontal section of buccal gingiva, these teeth are cut obliquely. A higher magnification of the enclosed area is shown in *Fig.* 13. The outer layer of gingival epithelium is shown cut obliquely and then again in its relationship to the epithelial cuff. Its keratin layer is clearly seen.

Another appearance of the epithelium obtained from a younger animal is shown in *Fig.* 14. Here the enamel epithelium has an irregular junction with connective tissue, somewhat similar to the rete pegs of the outer layer of the gingival epithelium. The portion of gingival epithelium overlapping the epithelial cuff has formed a lamina projecting into the connective tissue. In *Fig.* 15 this lamina is shown in a serial section in the process of uniting with a peg of enamel epithelium, enclosing a core of connective tissue in the process.

In one of the young animals the epithelial cuff was found to extend on to root surface.

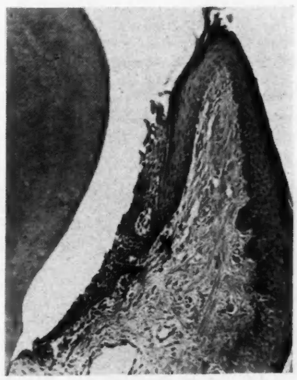

Fig. 15.—A neighbouring section to that shown in *Fig.* 14. The gingival epithelium has united with a projection of the epithelial cuff at X. Fullmer. (× 75.)

In *Fig.* 16 a maxillary molar is shown with the epithelial cuff terminating at the cement-enamel junction on the buccal side. On the palatal aspect, however, the epithelial cuff is on the root surface for almost its whole length. The relative heights of buccal and palatal bone margins should be noted. *Fig.* 17 shows a neighbouring section to that of *Fig.* 16. On the palatal side an artefact has occurred in the epithelial cuff. For about half its length this

epithelium was on enamel and the rest on root surface. A high magnification of this area is shown in *Fig.* 18. The epithelial cells from X to Y were on enamel surface, but have been pulled outwards with the split which occurred during preparation. The gingival epithelium can be distinguished from the epithelial cuff with little difficulty.

In *Fig.* 19 a hair is present between epithelium and enamel space. It penetrated as far as curvature of the crown and connective tissue permitted. It has been walled off by proliferating epithelium; leucocytes have migrated through the epithelium and are seen adhering to the hair.

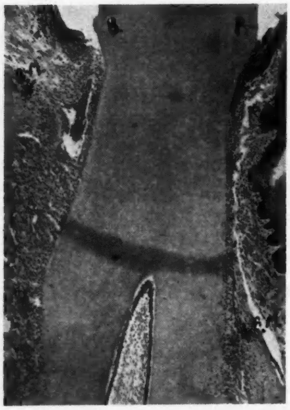

Fig. 16.—Buccolingual section of maxillary first molar. On the buccal side (B) the epithelial cuff terminates at the cement-enamel junction. On the palatal side (P) the epithelial cuff is almost entirely on root surface. *Note* the relative heights of buccal and palatal bone margins (B.M.). 29 days. H. and E. (× 42.)

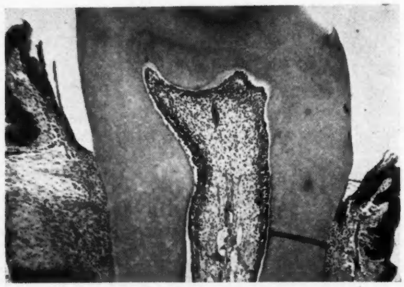

Fig. 17.—A neighbouring section to the one shown in *Fig.* 16. An artefact is present in the epithelial cuff as a split due to half the epithelial cuff being on root surface and half on enamel. 29 days. H. and E. (× 33.)

Fig. 18.—Magnification of the section shown in *Fig.* 17. The cells of the epithelial cuff from X to Y were on enamel surface. Space A is artefact. The gingival epithelium is easily distinguished from the epithelial cuff. 29 days. H. and E. (× 300.)

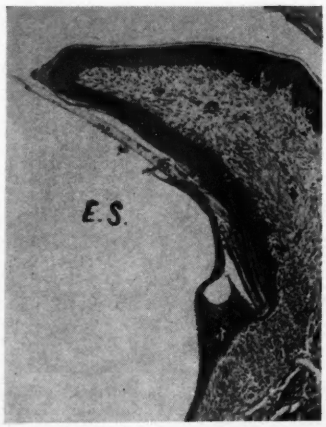

Fig. 19.—A hair has become impacted between the epithelial cuff and enamel. Penetration of the hair to the cement-enamel junction has been prevented by the curvature of the crown and the connective tissue. Enamel space, E.S. 29 days. H. and E. (× 80.)

DISCUSSION

An examination of this material suggests certain points for discussion.

Simple end-to-end fusion between gingival epithelium and epithelial cuff does not occur in the rat. Union between the epithelial layers

is obtained by reflection of the gingival epithelium along the epithelial cuff. This relationship tends to form at an early stage of eruption and is frequently preceded by proliferation of gingival epithelium over the superficial portion of the unerupted cusps. Immediately prior to eruption, the oral epithelium covers the superficial portion of the unerupted crown. It continues to proliferate over the enamel epithelium as eruption occurs. The enamel epithelium is therefore by-passed in the process of gingival maturation.

Close adaptation of the two epithelia generally exists for the whole distance of the overlap, but the deepest cells of the gingival epithelium may form a lamina which projects into the connective tissue. When this occurs, the enamel epithelium also tends to exhibit processes which project into the connective tissue. As the lamina from the gingival epithelium grows apically, it may link up with these processes.

The histological picture changes rapidly during the early stages of eruption. During the days immediately following eruption of the tooth into the mouth, the epithelial cuff becomes shorter, eventually reaching what appears to be a critical length. The length and morphology of both the cuff and epithelial overlap are conceived as being determined largely by the functional environment of the gingiva and the degree of organization of the corium of the gingiva. The collagen fibres of the corium become dense and well organized as the bone margin extends to its full height in relation to the cement-enamel junction. They then appear to be capable of controlling the growth of the epithelia of the cuff and gingiva.

The proportion of epithelial cuff covered by gingival epithelium is variable, particularly in relation to the degree of eruption. However, as the animal matures it is usual to find about one-half the length of the epithelial cuff covered. Only rarely is gingival epithelium found to approach the cement-enamel junction when the epithelial cuff itself extends only to this point. The gingival epithelium was not found to cover the epithelial cuff by continued growth along it. Proliferation stops short of the cement-enamel junction unless the epithelial cuff has proliferated on to root surface.

The tissue changes observed around the hair impacted in the cuff may be interpreted in the light of Waerhaug's findings in dogs. He found that following trauma to the epithelial cuff the cells directly affected underwent degeneration. Fluid exudation occurred and phagocytes were observed migrating through the epithelium towards the injured tissue. The basal epithelial cells proliferated to regenerate the cuff and in doing so tended to form processes which projected into the connective tissue. As the cuff was re-formed, the epithelium gradually assumed a more normal appearance with the epithelio-connective tissue junction becoming smooth. Within 21 days following the injury, the experimental side was indistinguishable from the control side. The minor degree of stratification assumed by the epithelium following injury did not progress to maturation but regained its original simple form following regeneration. Waerhaug (1952) also found that following gingivectomy the epithelial cuff which was formed from gingival epithelium did not undergo maturation.

The studies by Brill and Krasse (1958, 1959) are relevant to this discussion in that they have observed fluid exudation through the cuff in dogs and humans following minor stimulation. It is interesting to recall Black's observations in 1915 to the effect that the subgingival epithelium appeared to be bathed in a fluid exudate.

From these observations it would appear that the epithelial cuff in dogs and rats retains its ability to proliferate if the local environment is suitable. This is contrary to the suggestion made by Cohen (1959) that the epithelial cuff cells appear to lack any potential for proliferation.

The changes in the interproximal tissues as the teeth erupt are particularly rapid. The end-result is a union of the adjacent epithelial cuffs, but gingival epithelium is seen only in sections cut through the embrasure areas.

An interesting feature of the overlap is the distribution of the keratinized layer of the gingiva. In the mature gingiva this layer

extends from the gingival margin cervically in contact with the epithelial cuff. It gradually ceases as a well-defined layer before the deepest portion of the replicated gingival epithelium is reached. A keratin layer in this situation is interesting in that functional stimulation would appear, at least in theory, to be minimal. However, an examination of the rat gingiva under the dissecting microscope suggests that functional stimulation may be quite marked along the gingival margin, and in this way invagination of the keratin could be explained. It should be mentioned that the keratin develops after growth of gingival epithelium along the cuff has occurred and that to some extent the production of keratin in this situation may be simply an expression of the potential possessed by the gingival epithelium for cornification. Another point which arises in this context is the possible relationship between the extent of the overlap and presence of keratin. These are questions which at present cannot be answered.

In the rat the epithelial cuff, as it exists in the normal healthy animal, is derived from the enamel organ. In this way it may be looked upon as a connecting structure between gingival epithelium and enamel. It retains the potential for growth, both along root surface and into the gingival corium providing the corium permits such growth. To what extent the epithelial cuff is necessary as an intermediary between gingival epithelium and enamel is unknown at present. Waerhaug has shown that gingivectomy in dogs which removes the gingiva to the level of the cement-enamel junction is followed by regeneration to the former level and the formation of an epithelial cuff derived from gingival epithelium. We have yet to observe what happens when a similar experiment is performed on rats.

Growth of epithelial cuff along the root surface is shown in *Figs.* 16 and 17. It is interesting to find this in the absence of pathological changes in the connective tissue. It is either a developmental condition or it has occurred during the post-eruptive period. It is not possible to give a definite answer one way or the other, but it appears likely that the epithelial cuff grew on to the root surface following eruption because of the absence of well-developed fibres just apical to the cement-enamel junction. The absence of such fibres is explainable by noting the position of the bone margin in the specimen. It stops far short of the cement-enamel junction and consequently the lamina propria consists of poorly developed fibres orientated in a direction more parallel with the root surface than at right angles to it. Under these circumstances the gingival epithelium and the epithelial cuff apparently tend to grow down to a point where definite fibres exist. It is considered that stimulation for growth is provided by the functional environment of the gingiva.

Gottlieb considered that the growth of the enamel epithelium on to the root was the "fourth stage of eruption". However, it does not appear that this process can be accepted merely as an age change occurring as part of the maturation of the periodontium. Rather, it appears to signify a modification of the relationship between the gingiva and the tooth which is intimately related to the relationship between the alveolar bone and the cement-enamel junction. In those cases where the bone, due to either developmental or acquired defect, falls short of the cement-enamel junction the lamina propria of the gingiva is less dense in its structure, and this appears to permit proliferation of the epithelial tissue along the unsupported root surface. The gingival margin therefore recedes, and clinical recession occurs.

Clinical observations in man support this concept. The vestibular and oral surfaces of the dental arches are composed of the surfaces of the teeth in continuity with the gingiva. This close integration of hard and soft tissue makes up one functional surface. Tooth and gum cannot be considered as separate entities and treatment based on such an approach will frequently result in pathological changes. This is an example of the inter-relationship of form and function. On this basis the division of gingiva into marginal and papillary zones is useful only for the purposes of description and must be pursued cautiously as it has no functional basis. Given harmony between tooth

contour, bone contour, and bone height, the gingival margin will tend to mature to a certain position on the crown. This position is permanent so long as pathological changes are not induced by bacteria and food debris. Due to variations which occur in tooth contour, tooth position and alinement, development and position of alveolar bone, it is not surprising to find cases which exhibit delayed maturation or recession on to root surface. These are not diseases of the gingiva, but merely an expression of some other abnormality. However, it should be realized that these variations may predispose to inflammatory changes.

SUMMARY AND CONCLUSIONS

These observations on the epithelia in the dento-gingival junction may be summarized as follows:—

First, there appears to be a striking difference between the mode of union of gingival epithelium to epithelial cuff in man and in the rat. In the rat, gingival epithelium normally overlies the epithelial cuff and carries its keratinized layer with it. Due to the rapidity of eruption this relationship may not become established until the beginning of the second month.

Secondly, the epithelial cuff appears to be maintained at the cement-enamel junction by the gingival fibres, the degree of organization of these fibres being closely related to the development of the alveolar bone.

Thirdly, the process by which the gingival margin takes up its mature position, termed "gingival maturation", should be distinguished from the process by which the epithelial cuff grows along root surface, termed "gingival recession". In the rat, gingival maturation occurs as a result of growth of gingival epithelium along the connective tissue side of the epithelial cuff with concomitant atrophy at the gingival margin. In this way "detachment" of the epithelial attachment from the crown need not be postulated.

Further research is required before the whole picture of gingival physiology is obtained. The rat is a suitable animal for further work of an experimental nature, but when interpreting the results of such experiments the morphological differences between human and rat gingiva should be remembered.

The experiments of Waerhaug have altered the concept of the epithelial attachment so that the present picture is one of an epithelial cuff capable of regeneration following injury and supported by the collagen fibres of the gingiva. In view of the complex nature of the cuff in the rat and the presence of cornification in the gingival epithelium, investigation of the healing which follows experimental interference with the rat gingiva is required in order to correlate the response in this animal with that observed by Waerhaug in dogs.

Acknowledgements.—The author wishes to acknowledge the encouragement and facilities given by Dr. H. M. Goldman, Boston, and Professor Jens Waerhaug, Oslo, during the preparation of this paper, and to Professor P. J. Stoy, Belfast, for his help and advice.

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BOOK REVIEWS

NITROUS OXIDE IN DENTISTRY—ITS DANGERS AND ALTERNATIVES. By J. G. BOURNE, M.A., M.D. (Cantab.), F.F.A.R.C.S., Senior Consultant Anæsthetist, St. Thomas's Hospital, London; Consultant Anæsthetist, Salisbury Hospital Group. $8\frac{1}{2} \times 5\frac{1}{2}$ in. Pp. 181+x, with 22 illustrations. 1960. London: Lloyd-Luke (Medical Books) Ltd. 30s.

IN this well-written and carefully-compiled monograph the author clearly has a message for all anæsthetists and dentists. This is based on many painstaking investigations and inquiries, and from observing other anæsthetists administering nitrous oxide for dental extractions. He is left in no doubt that at best this gas is an indifferent method of producing unconsciousness, even in the hands of skilled anæsthetists, and that it is always potentially dangerous, as permanent brain damage can occur even without obvious anoxia.

Throughout the book one senses a prejudice against the method and often the tools instead of the workman are blamed in quoted cases of obvious mismanagement. If 14 teeth are removed from a healthy man without any oxygen being given (*Case* 9) there need be no surprise if death follows. Heavy-weight boxers, powerful alcoholic men (p. 19), and Royal Naval boxers (p. 21) are all known to be unsuitable cases to be anæsthetized with nitrous oxide and oxygen, and nothing is learned by recording unhappy sequelæ if this fact is ignored. At times one wonders if other observers, present at the time, would have agreed with the facts as stated, especially if it is admitted that each person can in all honesty record materially different views.

There is much discussion on fainting whilst breathing nitrous oxide in the sitting position, a procedure which Bourne considers to be dangerous; he believes that unless fainting is treated by an immediate change to the supine position, cerebral injury of some degree will follow and that this is a cause of delayed recovery after nitrous oxide anæsthesia. Though he records that McConnell, Goldman, and Mackintosh all doubt if they have ever seen a case of fainting, Bourne boldly states that this can only mean that fainting has been overlooked. To prove that a drop in blood-pressure accompanies fainting he reproduces the recordings of a man to whom he gave pure nitrous oxide for 40 seconds; at the end of this time the systolic pressure had dropped to 30 mm. Hg. One wonders if anyone should be anæsthetized sitting up without at least 20 per cent oxygen if the pre-anæsthetic blood-pressure is only 75 mm. Hg.

Bourne then describes at length the value of cyclopropane for dental and ambulant cases. By using his apparatus, a non-explosive mixture containing 25 per cent oxygen is obtained. With the standard technique an anæsthetic face mask covers both mouth and nose and in 60–90 seconds he produces anæsthesia which will last for at least one and a half minutes. If a longer time is required there are three methods available: (1) Replace the facepiece, even though blood is in the mouth—this is not recommended; (2) Give nasal nitrous oxide with 20 per cent oxygen, but this might produce an explosive mixture; (3) Intubate, though this should have been done at the commencement. With the standard technique consciousness was lost quickly though some degree of purposeless movement and muscle spasm occurred, frequently accompanied by breath holding. Movement could occur following the stimulus of extractions. Recovery from the commencement of induction to the point of being able to walk, was usually under five minutes. There were six failures in 3000 cases. Complications were laryngeal stridor and salivation; nausea and vomiting occurred, being reduced to 24 and 13 per cent respectively in later cases. Nausea occasionally persisted for hours.

The author summarizes by saying that the standard techniques would be safe in the hands

of the occasional anæsthetist and would meet the requirements in a high proportion of the dental and non-dental cases. In the remaining dental cases the patient should be given the benefit of endotracheal anæsthesia being administered by an experienced anæsthetist. This would mean radical changes in the Dental Service, including admitting two grades of anæsthetist. It seems a pity that he did not refer to the fact that at present there is no financial inducement towards a career in dental anæsthesia. Surely this fact alone accounts for the average standard of anæsthetic skill being lower in dentistry than in any other branch of surgery in this country. If only this long overdue reform was made, the safer and better standards so rightly sought by Bourne would follow, though history and not the reviewer will tell what drugs will be considered most effective.

H. B. C. S.

ATLAS OF CLINICAL PATHOLOGY OF THE ORAL MUCOUS MEMBRANE. A Practical Approach to Diagnosis. By Balint J. Orban, M.D., D.D.S., Professor of Periodontics, Loyola University School of Dentistry, Chicago, and Frank M. Wentz, D.D.S., M.S., Ph.D., Professor of Periodontics, Chairman of the Department, Loyola University School of Dentistry, Chicago, and Contributors. Second edition. $11 \times 8\frac{1}{2}$ in. Pp. 148, with 234 illustrations, 87 in colour. 1960. St. Louis: The C. V. Mosby Co. (London: Henry Kimpton.) £5 8s. 6d.

The first edition of this book, which appeared in 1955, was reprinted three times in its year of publication and has now run to a second edition. It is obvious, therefore, that the *Atlas* has filled a need and found acceptance.

In their preface to the second edition the authors attribute the success of the first edition to the charts and tables at the beginning of the volume, which they claim make it possible for the clinician to make a clinical diagnosis of an oral lesion. This may well be so, but surely is to be deplored. To base the diagnosis of lesions of the oral mucous membrane upon a system of charts and tables coupled with a series of coloured illustrations is to reduce the art of clinical pathology to the level of schoolboy stamp collecting or aircraft recognition.

The coloured illustrations include many which are good or at least adequate, but a high proportion are unfortunately not up to the standards currently expected. The monochrome illustrations of histological appearances are generally of a high standard. The opportunity has been taken in the preparation of the new edition to tidy up some irregularities in the arrangement of the subject matter but some inconsistencies still remain.

The real value of this book must surely be related to the faithfulness with which the illustrations reproduce the clinical conditions they represent. Too many of the reproductions fall so far short of the ideal as to be of questionable value in assisting the inexperienced clinician to recognize unfamiliar appearances. If the quality of the original photographs provided by the contributors is high, we may yet hope to see this *Atlas* greatly enhanced in value in future editions by an improvement in the quality of the colour printing.

J. A. P.

GENERAL ANESTHESIA IN DENTAL PRACTICE. By Leonard Monheim, B.S., M.S., D.D.S., Professor and Head, Department of Anesthesia, University of Pittsburgh School of Dentistry; Assistant Professor, Department of Surgery (Anesthesia), University of Pittsburgh School of Medicine, etc. 9×6 in. Pp. 461, with 114 illustrations. 1960. St. Louis: The C. V. Mosby Co. (London: Henry Kimpton). 78s. 6d.

This is a book which should prove to be useful to dental students and dentists who wish to have a better understanding of the principles underlying general anæsthesia. The chapters on anatomy and physiology of the respiratory, circulatory, and nervous systems give a clear picture without going into unnecessary detail. Throughout the book, emphasis is placed on the hazards of anæsthesia and how these may be avoided. Seven pages of references at the end of the book provide a useful guide to those who wish for more detailed information.

M. G. R.

AN INDEX FOR ASSESSING THE EFFICACY OF DENTAL TREATMENT IN THE CONTROL OF DENTAL CARIES

By **D. JACKSON,** M.D.S., D.D.S.
University of Leeds Dental School and Hospital

THE fillings–extraction ratio for many years has been used as an index of dental treatment, its use being facilitated by the ready availability of basic data presented in most public health reports. Although it is simple and has a clear meaning, this index does not adequately express the measure by which caries is controlled by dental treatment. If in a community having a total D.M.F. (decayed, missing, and filled teeth) of 100, there is one filling and one extracted tooth, then the fillings–extraction ratio is 1, as indeed it is if 50 teeth had single fillings and 50 teeth were extracted. The inadequacy of this index lies in its dissociation from current caries prevalence, in its lack of relationship to the total amount of effort made to control caries by treatment, and also in the diametrically opposed influence of filled teeth against extracted teeth. With respect to the last-named inadequacy it can be argued that a filling constitutes successful treatment and an extraction a treatment failure: hence in an index of successful treatment these two factors should legitimately be diametrically opposed. Against this it can be argued that untreated caries is the true treatment failure: hence these two factors, fillings and extractions, constitute successful treatment even if one factor is less successful than another. If one accepts this argument then both extracted and filled teeth can positively contribute to an index of treatment, providing filled teeth are given more statistical weight than extracted teeth. Further consideration of this problem leads one to the special circumstance of a tooth which is at the same time both filled and carious. This treatment constitutes partial success in that it is not so successful as a filled tooth otherwise sound, but more successful than an extracted tooth. We have, therefore, three grades of successful treatment, namely a filled tooth (F.), a filled-carious tooth (F.C.), and an extracted tooth (M.). If each grade is weighted according to its relative "degree of success", and the values summated we have the beginnings of an index which should reflect the degree by which treatment controls dental caries. It has previously been stated that such an index should be related to the current prevalence of dental caries, and this can be achieved by expressing the number of filled teeth (F.) to the total D.M.F., and by similarly treating the number of filled-carious teeth (F.C.) and also the number of extracted teeth (M.). Weighting is purely arbitrary, the only criteria being that it should be numerically simple and meaningful.

From such considerations the following index is proposed:—

$$\text{Treatment Index} = \frac{3(\text{F./D.M.F.\%}) + 2(\text{F.C./D.M.F.\%}) + (\text{M./D.M.F.\%})}{3}$$

It will be seen that if all D.M.F. teeth are filled and otherwise sound, the treatment index is 100 per cent, and that if all D.M.F. teeth are extracted, then the index is 33·3 per cent.

The treatment index (T.I.) can be used similarly to the D.M.F. index in that it can apply to groups of individuals or groups of individual teeth. It can, however, only be used up to the age of 25 years, beyond which age the D.M.F. ceases to be an effective measure of caries prevalence.

APPLICATION OF TREATMENT INDEX

1. Use of Index for Population Groups.—During 1958–59, 1863 individuals between the ages of 12 and 25 years were dentally examined in Leeds. From the basic data so obtained treatment indices for each group were calculated and these are presented in *Table I.*

In the community studied there is a general tendency for the index values to increase with age, which is particularly encouraging in view

of the fact that as age progresses more and more teeth are attacked. The index reflects the trend as shown in the other data in that as age progresses relatively more teeth are filled and more extracted. In the community studied it can therefore be stated that some headway is being made in the control of dental caries by treatment, but this headway is not great. If all D.M.F. teeth had been extracted the index would have been 33·3 per cent,

Table I.—THE TREATMENT INDEX (T.I.) VALUES CALCULATED FROM DATA PERTAINING TO 1863 INDIVIDUALS BETWEEN THE AGES OF 12 AND 25 YEARS EXAMINED IN LEEDS, 1958–59

AGE (years)	No.	D./D.M.F. per cent	M./D.M.F. per cent	F./D.M.F. per cent	F.C./D.M.F. per cent	D.M.F./100 (individuals)	T.I. per cent
12	1040	40·3	19·5	30·8	9·3	667	43·6
14	158	37·7	18·5	37·7	6·1	880	47·9
15	94	36·2	22·8	36·4	4·7	953	47·1
16	67	34·9	22·9	34·8	7·3	939	47·3
17	69	30·2	23·9	40·4	5·5	1048	52·0
18	86	31·4	27·5	35·7	5·4	1107	48·5
19	77	26·7	29·3	38·6	5·5	1260	52·0
20	62	23·6	24·4	46·3	5·7	1282	58·2
21	40	21·8	24·6	45·1	8·6	1342	59·0
22	42	21·4	30·3	44·5	3·7	1467	57·1
23	57	20·9	24·5	48·4	6·2	1425	60·7
24	41	16·9	31·9	44·0	7·1	1551	59·3
25	30	18·9	33·9	41·1	6·1	1590	56·5

Table II.—THE TREATMENT INDEX (T.I.) VALUES FOR 12-YEAR-OLD CHILDREN AT 17 LEEDS SCHOOLS

SCHOOL	No. OF CHILDREN	D./D.M.F. per cent	M./D.M.F. per cent	F./D.M.F. per cent	F.C./D.M.F. per cent	D.M.F./100 CHILDREN	T.I. per cent
1	42	59·0	18·0	16·7	6·8	738	27·2
2	102	53·6	21·2	20·9	4·3	578	30·8
3	45	45·7	30·9	23·0	0·3	618	33·5
4	9	46·9	24·1	19·3	9·6	922	33·7
5	41	46·0	22·8	23·6	7·6	610	36·3
6	110	44·3	27·7	21·3	6·6	609	34·9
7	15	45·4	25·0	27·3	2·3	587	37·1
8	66	49·6	13·3	25·6	11·4	715	37·6
9	41	46·2	19·1	26·7	8·0	702	38·4
10	24	34·5	12·4	24·1	29·0	604	47·6
11	117	34·5	22·4	34·9	8·2	727	47·8
12	59	33·2	22·8	38·9	5·1	602	49·9
13	49	36·4	11·6	35·1	16·9	806	50·3
14	91	34·2	16·5	37·7	11·6	633	50·9
15	68	32·9	12·9	32·3	21·9	693	51·2
16	68	32·7	19·8	40·4	7·0	713	51·6
17	93	31·7	14·8	45·4	8·1	718	55·7

Table III.—THE TREATMENT INDEX (T.I.) VALUES CALCULATED FROM DATA PERTAINING TO 12-YEAR-OLD GRAMMAR SCHOOL AND SECONDARY MODERN SCHOOL GIRLS AND BOYS IN LEEDS

TYPE OF SCHOOL	No.	D./D.M.F. per cent	M./D.M.F. per cent	F./D.M.F. per cent	F.C./D.M.F. per cent	D.M.F./100 CHILDREN	T.I. per cent
Secondary boys	309	46·9	19·5	26·4	7·2	636	37·7
Secondary girls	314	42·6	22·1	27·5	7·8	674	40·1
Grammar boys	184	32·9	15·6	41·7	9·8	676	53·4
Grammar girls	209	33·7	19·2	33·8	13·2	701	49·0

but at 25 years of age the index is only 56·5 per cent.

The index was particularly useful in assessing the control of dental caries by treatment in several schools, and to demonstrate the variation which can occur from school to school, the T.I. values for seventeen Leeds schools are given in *Table II*: the children examined were 12 years old. The values range from 27·2 per cent to 55·7 per cent, and in between these values there is a good scatter. This variation demonstrates that, when using the index in a community, as in 12-year-old Leeds schoolchildren for example, a good random sample is essential.

The number of 12-year-old schoolchildren examined permitted an analysis of boys and girls attending grammar schools and secondary modern schools, and the treatment indices for these groups are given in *Table III.* The indices clearly show that whereas there is little difference between boys and girls in each type of school, grammar school children have significantly higher index values.

2. Use of Index for Individual Groups of Teeth.—Treatment index values for individual groups of teeth are given in *Table IV.* These data have been obtained from Leeds 12-year-old children. It will be seen that the T.I. value for incisors, premolars, and first permanent molars are of the same order, the values being 42·1 per cent, 45·3 per cent, and 49·2 per cent respectively. The value for the second permanent molar is 29·5 per cent, this low value undoubtedly being due to the rapidity with which these teeth are attacked, and also to their relatively short eruptive life.

The balancing effect of the index with respect to fillings and extractions can be observed by comparing the treatment indices for premolars and first permanent molars. Of the former teeth, only 8·1 per cent of the D.M.F. teeth were extracted as against 33·6 per cent for first permanent molars, but because the former had a greater proportion of fillings, the treatment index values for these two groups of teeth are analogous.

Table IV.—The Treatment Index (*T.I.*) Values for Individual Groups of Teeth: Data from 12-year-old Leeds School Children

	D./D.M.F. per cent	M./D.M.F. per cent	F./D.M.F. per cent	F.C./D.M.F. per cent	D.M.F./100 Teeth	T.I. per cent
Incisors	55·4	1·6	38·6	4·4	6·6	42·1
Premolars	48·2	8·1	40·3	3·4	13·3	45·3
First permanent molars	23·8	33·6	29·0	13·5	89·9	49·2
Second permanent molars	68·6	0·2	25·9	5·3	54·5	29·5

DISCUSSION

From the data which have been presented it will be seen that the treatment index has considerable value in assessing the control of dental caries by treatment. Its main disadvantage lies in the necessity for full D.M.F. statistical data which are largely dependent on the diagnostic criteria of the examiner, but this is, of course, a problem common to all indices in which a subjective analysis has to be made.

The author is unaware of any other published statistical data sufficiently full to permit a comparative analysis, but basic criteria do permit observations to be made on the data presented in this paper. It will be recalled that a T.I. value of 33·3 per cent is obtained when all D.M.F. teeth have been extracted, and this level may be taken to be equivalent to an efficient casualty service. In certain schools examined, even this level was not achieved in 12-year-old children, although in most schools the T.I. was above, and in many, well above this level.

It will be recalled that if all D.M.F. teeth were successfully conserved, then the index would be 100 per cent. This is a level unlikely to be achieved because many mouths are overcrowded, and for this reason alone the best treatment for a carious tooth is often to extract it rather than conserve it. One cannot, therefore, give an ideal optimum figure, but

theoretically it should be possible to achieve a value of 80 per cent. The highest recorded T.I. value was 60·7 per cent at 23 years of age, but most other values fell very much below this level, indicating that in the community studied, the control of dental caries by treatment is by no means satisfactory.

SUMMARY

An index is designed to assess the degree by which dental caries is controlled by treatment. This index is simply computed by assessing the number of filled, filled-carious, and extracted teeth as a percentage of the total D.M.F. These values are respectively weighted in the ratio of 3 : 2 : 1, summated, and divided by 3. When all D.M.F. teeth are filled the index is 100 per cent and when all D.M.F. teeth are extracted the index is 33·3 per cent. The use of this index is demonstrated and shown to be of value in assessing caries control by treatment.

ABNORMAL POSITION OF RETAINED ROOTS

By J. S. HILTON COLLINGE, F.D.S. R.C.S. (Eng.)

Consultant Dental Surgeon, Liverpool Dental Hospital and School

CASE REPORT

A FEMALE patient, aged 24 years, complained of pain in the region of $\overline{76}|$. On clinical examination, there was a slight swelling in the sulcus, in the area where $\overline{6}|$ was missing. The history was of the extraction of the missing molar some four years previously under nitrous oxide and, apart from the usual post-operative soreness, there were no symptoms during that period. Subsequently she became aware of a slight swelling, which appeared from time to time and then apparently resolved. Three months later, the swelling reappeared with considerable pain.

Radiographs were taken and revealed two roots of $\overline{6}|$ which had migrated down almost to the lower border, and the mesial root lying below the inferior dental canal (*Fig.* 1). *Fig.* 2 shows the condition four weeks after operation.

Fig. 1.—Pre-operative radiograph showing relation of roots to inferior dental canal.

Fig. 2.—Radiograph taken four weeks after operation.

Under general anæsthesia, the outer plate was exposed and a window cut over the area where the roots were lying. The roots were well implanted and had to be divided before they could be removed. The wound was closed by primary suture and a drain was inserted for two days. The sutures were removed after a week, and the wound resolved without further incident. There was a slight paræsthesia affecting the corner of the lower lip, and this had practically disappeared within six weeks of the operation.

It would be interesting to know how these roots moved into this position. There may have been an infected area and softening of bone round the roots at the time of the attempted extraction, and these may have been pushed down in an attempt to recover the fractured roots.

Acknowledgements.—I wish to express my thanks to Mr. P. Bird for the radiographs, and to Mr. Bailey for the production of the photographs.

ABSTRACTS FROM OTHER JOURNALS

Bone

Bone Tissue.—This calcified connective tissue is intimately related to the daily practice of dentistry. It is composed of cells, intercellular fibres, and an amorphous ground substance; the latter two structures are organic to which inorganic salts have been added, and in this way bone differs from other connective tissues. On the basis of the relationship of the osteocytes one to another, and the structural pattern of the intercellular fibres, bone tissues can be classified as follows:—

1. *Woven Bone.*—This occurs in sites and situations where bone is being laid down rapidly, as in the callus of fractures, healing tooth sockets, in the fœtus, and during the first year of life. The fibres weave around the random-placed cells in an irregular manner. It eventually becomes resorbed and replaced by lamellar bone.

2. *Lamellar Bone.*—This occurs in the adult skeleton in layers. The oval-shaped osteocytes lie in lacunæ arranged at regular intervals. The cytoplasmic processes of the osteocytes lie within tiny canaliculi and link up with other osteocytes in adjacent lamellæ. The canaliculi aid in the exchange of nutrient and waste products. Each lamella is separated by a collagen-free zone which is called an incremental line. Osteocytes must not be too far away from the nutrient blood-supply if they are to remain alive, and this is catered for by the Haversian system. This system can be visualized as flat plywood boards bent to a circle. The central core becomes the Haversian canal containing blood-vessels and the canals pass at close intervals through the bone enabling osteocytes to be within 0·1 mm. of the blood-supply. In both jaws lamellar bone is found irrespective of whether the bone is compact or cancellous. The latter two terms are used to describe the gross appearance of bone.

3. *Bundle Bone* is a term used by Weinmann and Sicher to describe bone lining the tooth-socket into which periodontal membrane fibres are inserted. The bone has apparent lamellation, but the collagenous fibres all run in the same direction, unlike lamellar bone where the direction is changing in each lamella.

Bone Biology.—As in other tissues, mature bone-cells age and are replaced by new cells, and this may occur more rapidly in the bone of the jaws than in other bones because of frequent functional demands on it by the teeth via the periodontal membrane. Renewal of bone involves bone formation and bone resorption. Osteoblasts differentiate from mesenchymal cells or fibroblasts. Pritchard considers that the osteoblasts take an active part in the formation of the organic matrix by secreting precollagen which soon matures in collagenous fibres. During the process the osteoblasts become trapped between the collagenous bundles and transform into rather inert osteocytes. Bone growth is one of apposition; a continual laying down of more organic matrix which is subsequently calcified to become true bone. But bone resorption must occur if bones are to grow, and this entails the removal of inorganic salts, ground substance, fibres, and osteocytes all at one time. No single theory solves the problem of how bone is removed *in toto* and not part by part. There is evidence that osteoclasts are involved in the removal of bone; these are large, irregularly-shaped cells, with 12 to 20+ nuclei, and sometimes a striated border is observed. The cavities formed during bone resorption are called Howship's lacunæ.

Bone Behaviour.—When considering infection of bone, and following the work of Fish, the author's experiments showed that the osteocytes in the immediate vicinity of infection became necrotic, disappeared, and left empty lacunæ. A little distance away from the infection an intermediate area showed lacunæ which were empty and some which were not. The toxins diffuse radially via the canaliculi and the infection becomes less with increased distance from the central zone of necrosis. This is similar to the reaction in

other types of connective tissue during acute infection. It appears likely that no striking morphological change occurs in the collagenous matrix during infection. Once the osteocytes have been destroyed bone is no longer viable and is removed in some way from the body. The osteocyte is unable to exist in toxic surroundings so that bone resorption will occur round the periphery of the infection and a sequestrum is formed. Beyond this the toxic irritation has become less intense and there is stimulation of bone so that woven bone has begun to form. In an experiment to study bone repair, at the end of nine days a wound in bone was seen to be occupied by primitive connective tissue which began to organize at the base of the bone wound, and woven bone was seen to be in an active stage of formation. To demonstrate the behaviour of bone under pressure an elastic band was arranged to press tightly on one side of a rat's tibia. After nine days a dense fibrous tissue mass was seen at the base of the groove. At the edges where this tissue was attached to the lamellar bone, osteoclastic resorption was taking place, and beneath the fibrous tissue there was a heavy deposition of newly-formed woven bone.—TROTT, J. R. (1960), *J. Canad. dent. Ass.*, **26**, 347.

G. E. B. MOORE

Asepsis and Antisepsis in Dentistry

The author is professor of bacteriology at Melbourne University, and says that he does not advocate a standard of asepsis in dentistry which would be expected in major surgery, but one should aim at a standard consistent with a sound surgical technique together with an appreciation of the possible infectious sequelæ. To break the pathways of infection in dentistry the following procedures are recommended.

1. Moist-heat sterilization of instruments by autoclaving. For handpieces Crowley's emulsion allows the penetration of steam to the oiled working parts with minimal corrosion. The emulsion is 5 per cent light mineral oil, 1·25 per cent Span 80 (sorbitan mono-oleate), 1·25 per cent Tween 80, and water to 100 per cent plus a chemical preservative, 1–10,000 organic mercurial. It is stressed that the use of alcoholic solutions for sterilizing syringes and needles is a most dangerous method because the alcohol coagulates protein, and so fixes viral particles (infectious and serum hepatitis virus cause most concern) in inaccessible sites without destroying their viability. Since the incubation periods of these two diseases are 30 and 100 days respectively the causal relationship between a visit to the dentist and the onset of jaundice can be overlooked.

2. Dry heat is used for paper points, cotton-wool, etc., and broaches. Grossman's modification of the Flaherty molten metal sterilizer, in which common salt heated to 475° F. replaces the metal, is recommended.

3. Chemical sterilization of mucous membranes. This involves the mechanical removal and chemical destruction of the bacteria in the area and the maintenance of sterility during operation. For this purpose use isopropyl tincture of iodine—1 per cent iodine and 50 per cent of the alcohol. This is less irritating than tincture of iodine, B.P., and is equally effective.

4. Chemical sterilization of carious cavities with ATF zinc oxide lining cement. ATF was discovered in endodontia and is a mixture of neomycin, bacitracin, and polymyxin, and a fungicide. With some deference to differing dental opinion the author considers that the problem of the aseptic and antiseptic treatment of the deep carious cavity, with or without pulp exposure, can be resolved by the removal of all the macroscopically "infected" and discoloured dentine even at the risk of exposing the pulp; by the destruction of inaccessible organisms by lining the cavity with a diffusible, non-irritating, highly-bactericidal paste, and by the exclusion of oral contamination by effective sealing. For this antiseptic treatment the preparation is: ATF zinc oxide powder (ATF powder 100 mg.; sterile zinc oxide 1 mg.) and paraffin emulsion (liquid paraffin oil 25 per cent; Tween 80 15 per cent; propylene glycol 5 per cent; distilled water containing 1–10,000 organic mercurial to 100 per cent). The powder and emulsion are mixed to the required consistency and applied

as a lining prior to filling with the usual cavity lining.

5. Chemical sterilization of hands with 0·5–1·0 per cent chlorhexidine lotion. This is preceded by 2–3 minute no-brush hand-washing and drying on a freshly-laundered towel.

6. Chemical sterilization of gowns, fittings, etc., with 0·5 per cent alcoholic chlorhexidine spray (or swab in the case of solid objects, e.g., arm rests). Chair headrests should have disposable paper covers. Tumblers should be disposable.

The whole of the foregoing refers to the healthy patient. The T.B. patient would require all these measures plus the use by the operator of masks and gloves and a change of gown.—RUBBO, S. D. (1960), *Aust. dent. J.*, **5**, 61.

G. E. B. MOORE

The Relative Values of "Antidol" and Calcium Aspirin as an Analgesic

Some remarkable facts and figures concerning the consumption and toxicity of aspirin in both the insoluble and soluble forms are quoted by Wilkinson and Howe in their paper on relative values of "antidol" and calcium aspirin. There is considerable evidence to show that aspirin is not as innocuous as previously believed; some authorities state that consumption of salicylates appeared to be the cause of hæmatemesis and melæna in a high percentage of hospital admissions. As a considerable amount of aspirin is consumed for the relief of dental pain, a substitute which does not produce these harmful symptoms is urgently needed. This need prompted the authorities to investigate the comparative analgesic properties of aspirin and a recently introduced analgesic, "antidol". Each "antidol" tablet contains 250 mg. of salicylamide-(2-ethoxyethyl)-ether, together with 200 mg. of phenacetin and 50 mg. of caffeine.

Two hundred patients suffering from pain, which was graded either slight, moderate, or severe, were issued with a tube containing either 12×5 gr. (0·3 g.) tablets of calcium aspirin, or $12 \times 0{\cdot}5$ g. tablets of "antidol", with instructions to take 2 tablets every 4 hours as required. The tablets were identical in appearance and neither the patient nor the dental staff concerned with the treatment knew which drug was being used. The results were tabulated according to effectiveness following different surgical procedures, the degree of pain, and relative efficiency in different age-groups.

No conclusion was reached concerning gastric symptoms, but other workers have concluded that "antidol" does not influence stool occult blood content. The results of the survey indicate that "antidol" is more effective than aspirin in controlling dental pain. An interesting observation was that the analgesic efficiency of both aspirin and "antidol" increases with the patient's age. The authors were unable to explain this phenomenon.—WILKINSON, F. C., and HOWE, G. L. (1960), *Practitioner*, **185**, 316.

D. F. SOUL

DENTAL RADIOGRAPHY

A two-day course in dental radiography has been arranged for dental nurses and assistants, to take place on Thursday and Friday, May 25 and 26, 1961, at the Ilford Limited Department of Radiography and Medical Photography, Tavistock House North, Tavistock Square, London, W.C.1.

No fee is charged for this course. Application forms will be sent on request.

THE BRITISH SOCIETY FOR THE STUDY OF ORTHODONTICS

The Society will hold a Country Meeting in Bournemouth on May 5 and 6, 1961. The Meeting will include papers and demonstrations.

It has been decided that members of the profession who are interested in orthodontics but are not members of the Society may be granted temporary membership on payment of a fee of one guinea; this will entitle them to full participation in the Meeting.

Further information may be obtained from the Hon. Secretary, Mr. B. C. Leighton, Dental Department, King's College Hospital, London, S.E.5.

FURTHER OBSERVATIONS ON EARLY LOSS OF DECIDUOUS MOLARS

By E. K. BREAKSPEAR, L.D.S., D.Orth. R.C.S.(Eng.)
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PASSIONS tend to cool with time; and if this subject no longer arouses the same fierce arguments as of old, it is because we have learned that truth is to be found on both sides. Premature loss of deciduous molars is not so profound a cause of malocclusion as was formerly thought (Lundström, 1955); nevertheless it presents a continuing problem to all who have to do with children's dentistry, and its effects cannot be ignored.

With the growth of interest in fundamental orthodontics in the last decade, the effect of adventitious factors such as early extractions has become a relatively neglected field. I believe, however, that quite apart from any clinical applications there is a treasure-house of knowledge waiting to be unearthed here, capable of throwing light on many wider problems.

There are eight deciduous molars in each normal mouth, and one cause of confusion in the past has, I feel, been insufficient separation of the differing effects of extracting one of the eight rather than another. In my previous paper on this subject (Breakspear, 1951) I tried to clarify the position, concentrating mainly on single extractions. Perhaps the most important finding at that time was the high rate of space loss for the second deciduous molar compared with the first, especially in the upper arch. There was also in my material a number of cases of double extractions, too small for detailed analysis, but enough to show some rather surprising tendencies.

The purpose of this paper is to examine these tendencies in a larger material, and to discuss possible causes. I therefore propose to confine myself to the differences between double and single extractions and the points arising, leaving other matters to another occasion. In this context, I mean by "double extractions" the simultaneous extraction of two adjacent deciduous teeth, i.e., D and E together. The principal studies on this subject in general since 1951 have been those of Lundström (1955), Clinch (1958a), Linder-Aronson (1958), and recently Halikis (1960). Much valuable information is contained in these reports, but none of them refers directly to the problem of double extractions, which I believe raises new issues. The way therefore seems to be clear for a fresh approach.

METHOD OF INVESTIGATION

The method preferred was that used in the previous study, namely a cross-sectional survey carried out before the premolars had erupted. We know that some of the space lost may be regained when the premolars erupt (Seipel, 1948), and other rectifying adjustments may occur; but I regard these as complicating factors. The best time to study the mechanism of space loss is when it is actually taking place. Even if partial recovery occurs later, it is, I think, reasonable to assume that the greatest permanent damage is likely to be seen in those cases where the space loss is greatest at an intermediate stage; though this has not yet been proved.

The method, however, presents a number of difficulties. The first is the extreme variability of the effects under study (*Fig.* 1). In Case 465, four years after extraction of |E, the space has completely closed. At the other end of the scale, Case 404 (*Fig.* 2) shows a negative space loss nearly three years after extraction of |DE. This is the kind of anomaly which aroused my curiosity and led to the present research. So wide a range does not make statistical work impossible, but it increases the difficulty of obtaining significant results, and in some instances one has to exercise clinical judgement and objective reasoning without precise mathematical support.

Given at the meeting held on October 10, 1960.

The second problem is that of adequate controls. So far as each individual case was concerned, I compared the remaining space, in unilateral extraction cases, with the mesio-distal length of the corresponding tooth or comparable groups of approximately equal number, two of which contained cases of unilateral extraction of two adjacent deciduous molars, in the upper and lower arches respectively; the other two consisting of cases with

Fig. 1.—Case showing complete space closure, in upper arch.

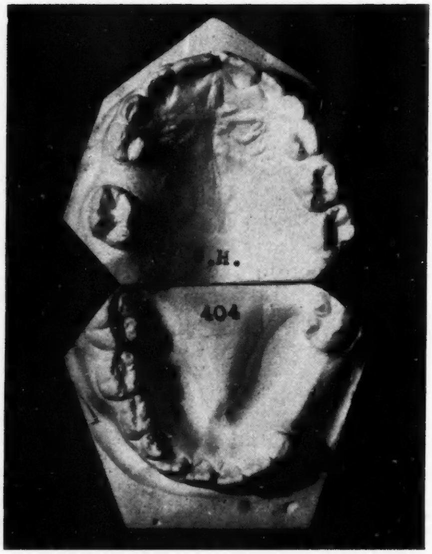

Fig. 2.—Case showing no space loss, in lower arch.

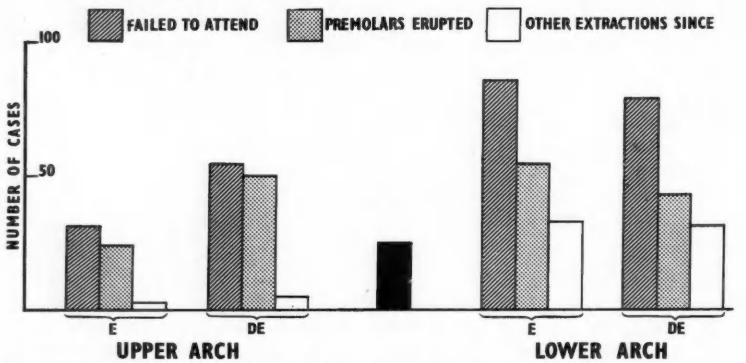

Fig. 3.—Principal causes of "wastage". The black column represents the number of cases suitable for measurement in each group (25 approx.).

teeth on the opposite side. Lundström (1948) has shown the small amount of variability in tooth size between left and right sides of the same individual. The aim was to find four unilateral loss of one second deciduous molar only, under analogous conditions. By comparing the latter results with those for a similar group in the 1951 study, an indication

could be obtained of the reliability of the method.

The third difficulty is that of wastage (*Fig.* 3). In addition to those showing loss of control teeth, the following types of case were excluded: those with any premolar erupted in the quadrant under observation; those whose first permanent molar was not present behind the gap; and those with other extractions in the quadrant under observation.

The treatment records of the Coventry School Clinic were searched for eligible cases, who were then asked to attend for examination. It was originally intended to find 4 groups of 50, making 200 in all. It soon became clear, however, that this would not be possible, and the "target" was reduced to 4 groups of 25, making up 100. The actual number measured was 102.

In order to achieve this, the number asked to attend was 618. The reasons for the very high wastage are shown to be: first, failure to attend; second, eruption of premolars; third, other relevant extractions since the last recorded visit to the Clinic. Comparing the 4 groups, it can be seen that the lower "single" and lower "double" groups were reasonably comparable. The 2 upper groups were of a similar pattern as between themselves, differing from the lower groups in earlier eruption of premolars (Gardiner, 1955), and fewer losses by caries (Halikis, 1960). The total wastage was considerably less in the upper E group than the others; though the possible effect of this on the results in general is not immediately clear.

Considering now the internal comparability of the 4 groups, *Table I* shows, I hope, a reasonable similarity so far as time factors are

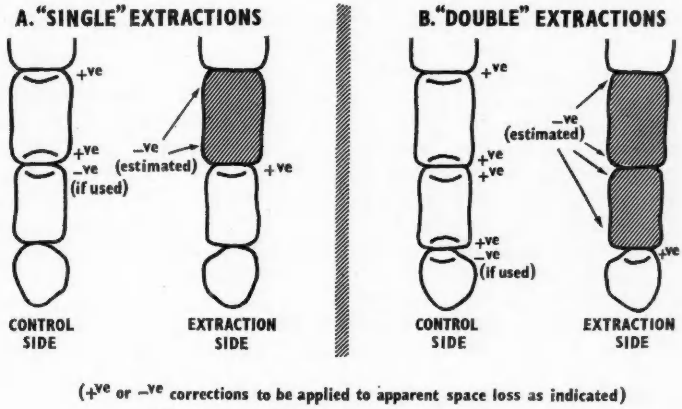

Fig. 4.—Corrections due to interstitial caries.

Table I.—COMPARABILITY OF GROUPS

		Group	Mean Yr.	Mean Mth.
1. *Age at time of extraction*	(Overall mean: 6 yr. 7 mth.)	Upper E	6	4
		Upper DE	6	9
		Lower E	6	7
		Lower DE	6	9
2. *Interval since extraction*	(Overall mean: 1 yr. 10 mth.)	Upper E	2	3
		Upper DE	1	5
		Lower E	1	10
		Lower DE	1	10
3. *Age at time of examination*	(Overall mean: 8 yr. 5 mth.)	Upper E	8	7
		Upper DE	8	2
		Lower E	8	5
		Lower DE	8	7

concerned. The chief difference is in the average interval between extraction and measurement, which was higher than average in the upper E group, and rather lower in the upper DE group: this will be discussed later. The 2 "lower" groups were again comparable. The overall *ranges* were as follows: age at time of extraction, 3 years 9 months to 9 years 10 months; interval since extraction, 4 months to 4½ years; age at examination, 6 to 11 years.

About twenty observations were made on each case measured, but only the following concern us here: mesiodistal dimensions of extraction spaces and control teeth measured clinically to the nearest half-millimetre; encroachment of contact points by caries, judged anatomically to the nearest half-millimetre; tongue behaviour; cuspal lock; and right- or left- handedness in writing. Models were made in cases of particular interest, but not as a routine.

The largest source of error in this type of study is probably the encroachment of the extracted teeth by caries, which can only be estimated. Fortunately there is some basis for doing this, as explained in the 1951 paper, and the graph constructed then was used on this occasion. It will not always be correct for an individual case, but will be somewhere near the mark for a group of cases. The corrections applied are shown in *Fig.* 4. In general, encroachment of the control teeth would make the space loss seem too low, and call for a positive correction; while encroachment of the extracted teeth, by interstitial caries, would make the loss of space due to the *extraction* appear too high, requiring a negative correction.

It was not easy to decide what figure to use for prior encroachment in cases of double extractions, but I eventually settled on the arbitrary one of 1·6 times the allowance for a second deciduous molar alone. This, I think, is a fairly realistic figure, and I have used the same proportion to formulate the theoretical value "V", which will appear later.

After making these corrections, the figures were converted into the standard form of "Mean Rate of Space Loss", in millimetres per year, which was the basis of comparison. The overall mean was 1·75 mm. per year, but the individual cases ranged from plus 5·5 to minus 2·8 mm. per year; these values are, however, to some extent artificial. The actual loss observed would depend on the length of time during which the space loss had been proceeding, and prognosis would likewise depend on the period likely to elapse before the premolars might erupt.

The question of the linearity of tooth movements will rightly be raised at this point. So far as I could judge by my 1951 results, the rate of space loss appeared to be fairly steady in general, but with a tendency for space to be lost a little more rapidly at first, and somewhat less rapidly as the premolars prepared to erupt. By comparing groups with a comparable range of time intervals, these differences would tend to be evened out; in the case of the two upper groups, however, any error due to this cause would be in the direction of artificially lowering the upper E rate and artificially raising the upper DE rate.

In this investigation the basis of comparison is not the individual but the group. Many possible sources of error are reduced by this means, even in the small numbers available. In spite of the variability, it was found that sub-groups of as few as 10 or 12 cases did, in fact, offer reasonable possibilities for comparisons to be usefully made.

Dockrell (1960) confirms the levelling effect of group analysis in connexion with possible individual growth spurts, over an age range which covers that of our present subjects, with very few exceptions.

RESULTS OBTAINED

Let us now consider what we might expect to see (*Fig.* 5). If any break in the dental arch were of equal importance, each of the columns representing mean rate of space loss would be of the same height, as in (*a*). If, however, the rate of space loss were proportional to the amount of tooth substance lost, the relation of the D, E, and DE groups would be as in (*b*), where the third column is the sum of the previous two.

What we actually see is a modified version of this, as in (*c*). The third column is not the

sum of the first two, but is slightly less than the second: in other words, the effect of removing D and E together appears to be no worse, and if anything slightly better, than that of removing only the E. This was the effect I had noticed in 1951, and the figures must now be considered in more detail (*Fig.* 6).

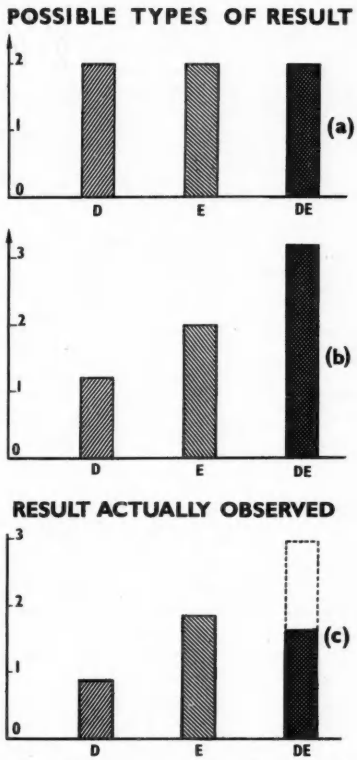

Fig. 5.—Possible types of result, and actual results. Mean rate of space loss in mm. per year.

The basic similarity in the pattern for upper and lower arches can be seen. The theoretical value "V" has been put at 1·6 times the observed result for the E column, and in each case the actual result in double extraction cases is significantly below it. The difference between the E and DE columns is negligible in the upper arch as it stands, and in the lower arch does not reach the level of significance. It can, however, be said that there is no evidence that the effect of double extractions is any worse, on the average, than that of removing the second deciduous molar alone. For those who wish to examine the actual figures more closely, I have added a short statistical appendix.

Some further points should be noted. I have included the findings of the 1951 study, which related to single D and E extractions only.

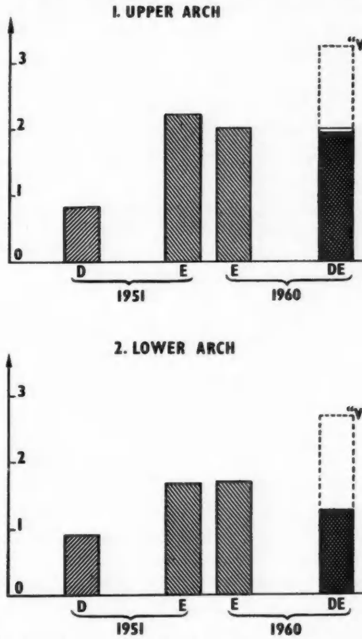

Fig. 6.—Actual result broken down. Mean rate of space loss in mm. per year.

The correspondence of the duplicated E columns in the two arches is a measure of the reliability of the method. In the lower arch the correspondence is very close, and in the upper arch fairly close; there is, however, reason to believe that the old upper E column is a little too high, owing to the use of a less precise method of calculating prior encroachment in 1951. The upper DE column should be slightly reduced, as shown by the bar, on account of a variation in the left–right composition of the sample; and an analysis of the influence of the different time interval between

extraction and measurement in the 2 upper groups, mentioned earlier, would probably tend to depress the upper DE column still further, thus producing a relationship more nearly resembling that in the lower arch. It is therefore felt that the general approach is justified, and that in spite of small numbers, useful comparisons can be made.

It should also be noted that the lowest rate of space loss is still that for the *first* deciduous molar. Although the double extraction columns tend to be slightly lower than the E columns, they are nevertheless higher than the D columns. This emphasizes the importance of preserving the second deciduous molar whenever possible.

POSSIBLE EXPLANATIONS

If my interpretation is correct, there seems to be some "checking factor" at work (perhaps more than one) tending to reduce the space loss in cases of double extractions. I believe the most important of these to be the action of the tongue, which can more easily enter a larger space than a smaller; the cheek muscles may also play a part. Another factor which operates in some cases is the cuspal lock: slight over-eruption of the opposing teeth may be more likely when 2 teeth are missing than when only 1 is lost.

These factors would influence both upper and lower arches; some might have a relatively favourable effect on the lower arch especially. One is the Curve of Spee, which may facilitate cuspal lock in the lower arch; another is the fact that more lower deciduous molars are lost than uppers (Halikis, 1960). The importance of this is that, when the extraction space is beyond a certain size, tongue pressure may become less effective through diffusion; this would happen more often in relation to primary upper extractions than vice versa. A further point is the anatomical proximity of the tongue to the lower arch; any or all of these might be responsible for the apparently greater checking effect in the lower arch. The efficiency of the checking action might also be affected by, for example, the type of swallowing.

An attempt was made to confirm these theories statistically and clinically. From the statistical point of view, the material presented difficulties due to small sub-groups and high variability. Nevertheless it was possible here and there to find sufficiently comparable elements. The first of these is set out in *Table II A*.

Table II.—SIGNIFICANCE OF OBSERVATIONS

A

1. *Significant results* (difference more than 2 times Standard Error):
   - *a.* Good cuspal lock more frequent in "lower" groups than upper.
   - *b.* Tongue bulge more frequent in "double" groups than single.
     (*Deduction*: Low rate of space loss in "lower double" group may be attributable to these factors if they are favourable.)
   - *c.* Diversion of tongue bulge more frequently associated with primary upper extractions than with lower.
     (*Deduction*: This may also assist *lower* groups, if favourable.)
2. *Sub-significant result* (difference between 1·5 and 2 times Standard Error):
   - *d.* In lower E group, cases with tongue bulge showed less rapid space loss than cases without tongue bulge.
     (*Deduction*: Tongue bulge appears to be advantageous.)

B

3. *Non-significant but possibly relevant results* (difference below 1·5 times Standard Error):
   - *e.* In lower DE group, cases with good cuspal lock showed less rapid space loss than cases with poor cuspal lock.
     (*Provisional deduction*: Good cuspal lock appears advantageous.)
   - *f.* In upper DE group, cases with diverted tongue bulge showed more rapid space loss than cases with non-diverted bulge.
     (*Provisional deduction*: Diversion of tongue bulge appears to be disadvantageous to the arch of primary extraction.)
   - *g.* In lower DE group cases with tongue bulge, cases with teeth-together swallow showed less rapid space loss than cases with teeth-apart swallow.
     (*Provisional deduction*: Bulge mechanism appears to act more efficiently in presence of teeth-together swallow.)

Since actual figures for such small samples might be misleading, I have deemed it best to express them qualitatively, though fuller details are given in the Appendix. I have also grouped them in order of significance. For the benefit of those unfamiliar with statistical procedure, I will explain that the Standard Error is a measure of the possible influence of chance in a sample of a given size and variability; a difference of twice the Standard Error represents a finding that would

occur by chance only once in 20 times, and is accepted by convention as significant. Significance is only a relative term, however, and we are entitled to accept a greater or lesser level for a particular purpose if we wish to do so.

In order to make progress in this peculiarly difficult field, I suggest that, whilst welcoming full statistical significance when it can be obtained, we should cautiously accept a level of 1·5 times the Standard Error, pending further evidence. We may also quite properly take note of findings which are not significant, since these may be real differences, though not found in sufficient numbers to be fully provable (Bradford Hill, 1959). Some of these are shown in *Table II B.*

It will be evident that the results susceptible to analysis did in fact fit into the pattern expected; if the pattern emerges more clearly in some respects than in others, it is for each of us to decide at what point to reserve judgement.

It is interesting to record in passing that results in the upper arch sometimes appeared anomalous. Apart from errors due to sampling technique, this may reinforce Clinch's observation (1958a) that more light is needed on the different response in upper and lower arches.

Fig. 7.—Case showing good space maintenance, without good natural spacing.

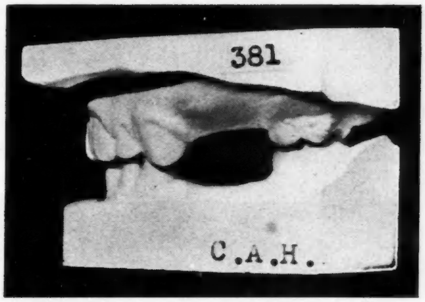

Fig. 8.—Diversion of tongue bulge by additional extractions.

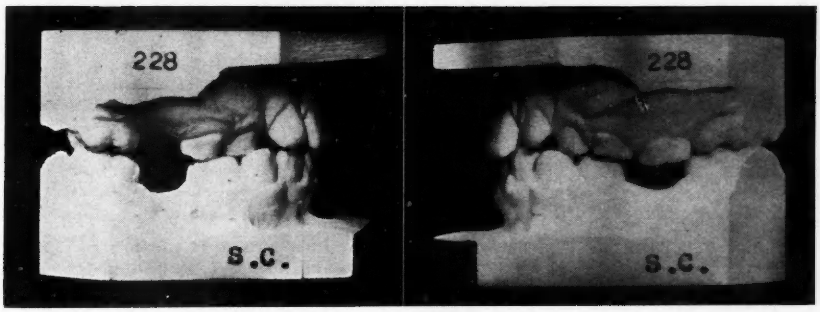

Fig. 9.—Left and right sides of same case compared: diversionary effect suspected on right side.

CLINICAL CASES

Some clinical cases will now be shown, which illustrate these points. Space maintenance *without* good natural spacing is seen in

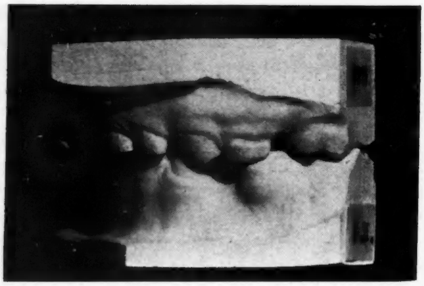

Fig. 10.

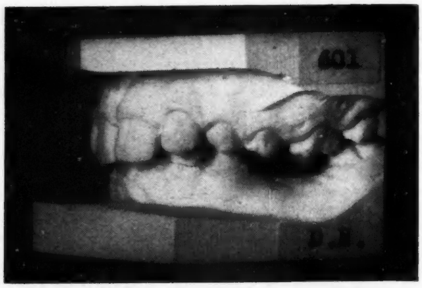

Fig. 11.

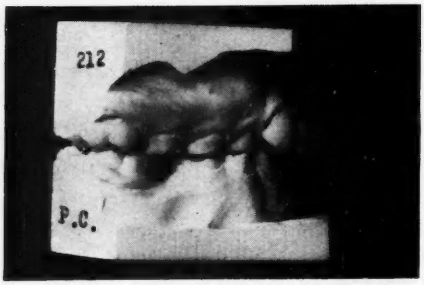

Fig. 12.

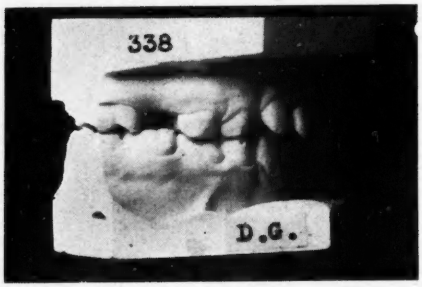

Fig. 13.

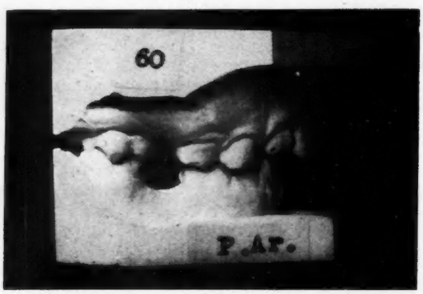

Fig. 14.

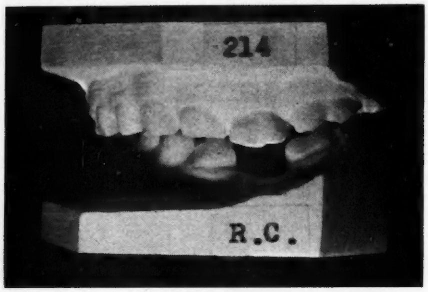

Fig. 15.

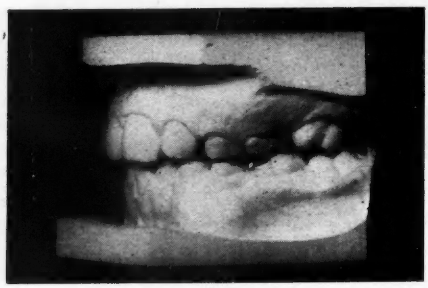

Fig. 16.

Fig. 10.—Case giving little opportunity for tongue bulge.

Fig. 11.—Case showing posterior cuspal lock.

Fig. 12.—Partially effective cuspal lock in spite of attrition.

Fig. 13.—Cuspal lock rendered ineffective by caries.

Fig. 14.—Case showing secondary cuspal lock of permanent molars.

Fig. 15.—Weakening of cuspal lock by tilting of lower molar.

Fig. 16.—Weakening of cuspal lock by tilting of upper molar.

Case 352 (*Fig.* 7), $1\frac{1}{4}$ years after loss of $\overline{DE}|$. Tongue bulge has apparently been effective, in spite of strong lip pressure.

Case 381 (*Fig.* 8) shows diversion of tongue bulge by additional extractions in the lower arch, reducing its effectiveness above. In Case 228 (*Fig.* 9), both sides of which are shown, the lower E space has been better maintained on the left side, in spite of earlier extraction. This I ascribe to diversion of the tongue bulge on the right side; though cuspal lock on the left may also have helped. A poor combination from the point of view of tongue bulge (though, as Hopkin pointed out in 1958, not necessarily from that of cuspal lock) is shown in Case 375 (*Fig.* 10).

Cuspal lock is probably not often fully effective in the late deciduous dentition, owing to attrition. Partial effects may, however, be seen, as in Case 601 (*Fig.* 11), which was noted as "partially effective posteriorly". In Case 212 (right) (*Fig.* 12) there seems to have been some effect, in spite of attrition, though the long interval since extraction has produced considerable total space loss. The action of caries in destroying what might have been a useful lock is seen in Case 338 (*Fig.* 13), where the carious distal surface of $\underline{D}|$ is unable to engage the slightly over-erupted $\overline{E}|$.

A secondary lock may be formed at a later stage, as in Case 60 (*Fig.* 14), where the upper first permanent molar, having achieved a stable Class II articulation, can now be restrained by the lower first molar. Too often, however, such a lock is weakened by tilting of the lower molar (Case 214, *Fig.* 15), or the upper (Case 212 left, *Fig.* 16).

DIFFERENCES BETWEEN LEFT AND RIGHT SIDES

(*Fig.* 17)

We now turn to the second and, I venture to hope, more interesting part of my paper. At any rate we shall be picking our way across a new and largely uncharted field, and I hope to share with you some of the fascination I experienced in exploring it.

In the 1951 study, note was taken of the differences between left and right sides, and in the case of the second deciduous molar there seemed to be a tendency for space to be lost more rapidly on the left side. I suggested at the time that this might accord with the conception of the left side of the body as the

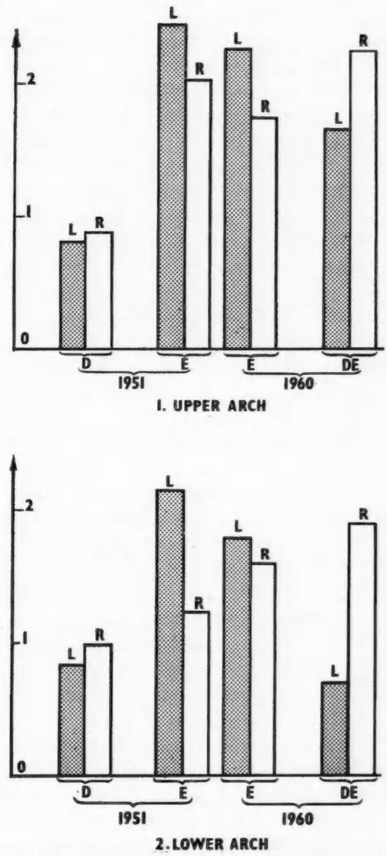

Fig. 17.—Differences between left and right sides (after correcting for "social" left-handedness). Mean rate of space loss in mm. per year.

"weaker" side. I also noted, however, that in the small number of double extraction cases then available, the reverse seemed to be the case. This was the other aspect of the subject which I wished to follow up in particular.

It can be seen from the graph that the space loss is again more rapid on the left side in the upper and lower E groups, though with random

differences from the earlier results, and less marked in the lower arch. As explained earlier, the 1960 figures are to be preferred. In the double extraction groups, however, space is lost more rapidly on the *right* side, thus confirming what was suspected in 1951, subject to some statistical qualification. This effect is seen more clearly in the lower arch, and it seems possible that the same factor which is responsible for the checking effect in the lower DE group generally may also be responsible for the additional checking of space loss on the left side in this group. This, in fact, appears to be borne out by subsequent investigation; but as the field is a new one, some introduction must first be given.

The distribution of primary extractions between the two sides was fairly even, except in the upper DE group, which had a preponderance of extractions on the right side (16 right against 11 left). This does not affect the means shown here, but has a slight effect on the average for the whole group, as pointed out earlier.

Looking for some unknown anatomical or physiological factor affecting the "dominant" side more (or less) than the other, I had felt initially that the first step was to sort out the left-handed children and transfer them to the opposite side. The graph therefore refers strictly to the dominant and non-dominant sides, and remarks affecting the right-handed majority must be reversed for the left-handed minority.

Of the 102 cases in the sample, 9 were found to be left-handed by simple questioning. This agrees with the estimates of other workers; but it relates to what may be termed "social" left-handedness. It is known, however, that a number of "genetically" left-handed children (as determined by hair-whorls, etc.) become socially right-handed, either through education or imitation (Eustis, 1949, and others). The proportion of true left-handedness (known as sinistralism) is therefore higher than 9 per cent; estimates vary from about 17 per cent upwards (Friedman, Golomb, and Mora, 1952; Woo and Pearson, 1927).

We may therefore suppose that an unknown number of genetically left-handed children (possibly as many as 9 or 10) were included on the right-hand side of the investigation as determined by questioning. These would tend to obscure the real differences present.

The importance of this is statistical. The difference in mean rate of space loss on left and right sides in the lower DE group is sub-significant (1·7 times the Standard Error); but for those who have qualms about accepting this level of significance, I would suggest that, if the true proportion of sinistralists were known and allowed for, conventional significance would probably be reached. It is also worth noting that this tendency had been observed in a small group in 1951, and the addition of these cases to the present material would also raise the level of significance.

POSSIBLE EXPLANATIONS

If these differences are not due to chance, some explanation must be sought: why, in cases of double extractions, should the space loss be less rapid on the left side? Five possible theories suggest themselves; there may be others. I will examine each in turn.

1. Theory of the Biological Inferiority of the Left Side.—This was the first possibility to which I turned. The inference would be that the left side is a little more plastic than the right; hence more easily affected by adverse forces, but by the same token, more responsive to a restoring force such as the tongue. This theory once had a considerable following, but now seems to be out of fashion. A strong argument in favour of it is the fact that cleft palates occur twice as frequently on the left side as on the right (Glass, 1959).

Unfortunately, the theory seems to break down if pressed. Preferences and "dextralities" undoubtedly exist, and have been related to a dominance of one side of the cerebral cortex over the other (Peterson and Fracarol, 1938); but these distinctions are by no means absolute (Woo, 1928; Wevill, 1928), and there is great power of adaptation and transference following injury (Bethe, 1932). Perhaps the strongest argument against it is the fact that, on the average, the right eye is no better than the left eye; and that where an ocular preference is evident, no correlation

can be found between ocular and manual dextralism (Woo and Pearson, 1927).

2. Theory of Differential Tongue Activity.—If it could be shown that the tongue muscles were normally stronger or more active on the left side, the results would be explained. Unfortunately, however, the only investigators of the subject, so far as I am aware (Block, Disher, and Froeschels, 1957), found that right-handed people were right-tongued; the congruity observed (70 per cent) being greater than that for foot, ear, or eye dominance.

It may be asked, why does this not have a greater effect ? The answer may be that every muscular action is accompanied by a reciprocal thrust somewhere, and there may be a reciprocal bulge on the non-active side which cancels out the primary effect. Froeschels (1960) also noticed that local factors, such as prostheses, may affect the tonguedness, and this may be relevant in reverse.

3. Theory of Differential Eruption of Premolars.—We know that the vigour with which the premolars erupt is capable of reopening some of the lost space. To account for the differences observed, the premolars would have to erupt earlier on the left side. Braccesi (1960a, b) found, however, that in normal children eruption times were symmetrical on left and right sides. In children with abnormalities, eruption was asymmetrical, but it was irregular, following no clear pattern.

4. Theory of Differential Incidence of Tongue Diversion.—If additional extractions occurred more frequently on the right side, the tongue bulge might be weakened by diversion on that side more often. Salzmann (1937) has observed a slight difference in the frequency of extraction of first permanent molars on the two sides; but so far as my sample was concerned, diversion of tongue bulge occurred with equal frequency on left and right sides. More recently Halikis (1960) has reported no significant difference between left and right sides in the incidence of deciduous molar extractions.

5. Theory of Skeletal Asymmetry.—So far we have sought without success to find a differential checking factor operating more strongly on the left side. Suppose, however, that the checking agent is constant, but its field of operation is asymmetrical; this might explain the results, and however fantastic it may appear at first sight, this is the view which I have come to hold.

We are accustomed to thinking of the tongue as a primary moulding force; but if over-riding skeletal or muscular factors intervene, the tongue becomes a secondary force producing limited local effects. In severe skeletally post-normal cases, for instance, proclination of the lower incisors may be seen. Clinch (1958b) and Harvold (1951) have shown the effort at adaptation in grossly abnormal cases. It seems logical to suppose that, if some asymmetry were *normally* present, the tongue would come into closer contact with the dental arches on the more inset side. The response to be expected would be some type of tooth movement; but if this were prevented by external muscular force, the effect of closer apposition of the tongue might be seen in a more efficient checking action in cases of early loss, and perhaps in a differential caries incidence, due to an improved scouring action.

This might not occur in every case: since we are dealing with the mean, the asymmetries might be widely distributed but slight in degree, or more marked but confined to fewer cases.

Asymmetries occur in the body generally (an obvious example being the position of the heart); and we know, for instance, that the right humerus is usually a little longer than the left. Harvold (1951) has demonstrated asymmetries of the skull; Berger (1957) and Jackson (1937) have drawn attention to asymmetries of the face. There is, however, very little material relating to asymmetries of the dental arches themselves, and in order to examine this question I decided to make a few simple tests.

DENTAL ASYMMETRIES OBSERVED

My starting point was the Presidential Address given before this Society by Rix (1946). He observed that, of 27 children with atypical swallowing habits, 6 showed linguo-occlusion of upper cheek teeth on the left side, but only 1 did so on the right. I examined two representative samples of orthodontic

patients who had come under my care at different periods, in Coventry and in Birmingham respectively. I also reviewed the 102 research patients, for whom I had measured the relation of the upper and lower dental centre-lines.

The three asymmetries which I looked for were: (1) unilateral linguo-occlusion of upper cheek teeth; (2) unilateral linguo-occlusion of one or more upper incisors; (3) unilateral post-normal occlusion in substantially unmutilated cases. Note was also taken of the relative caries incidence on the two sides. The results have been classified statistically as before, but more detailed figures will be found in the Appendix. The most reliable results are shown in *Table III A*.

Table III.—SIGNIFICANCE OF ASYMMETRIES

A

1. *Significant results* (difference from expectation more than 2 times Standard Error):
   a. In 102 research patients (mean age 8 yr. 5 mth.), lower dental centre-line was displaced to the right more frequently than the left.
   b. The mean displacement was 0·35 mm. to right of upper centre.
2. *Just or nearly significant results* (difference 1·9 to 2·0 times Standard Error):
   c. In a group of 200, consisting of 125 practice cases (mean age 10 yr. 8 mth.) in Coventry, and 75 clinic cases (mean age 11 yr. 2 mth.) in Birmingham, unilateral linguo-occlusion of upper cheek teeth occurred more frequently on the left side than the right.
   d. In the same group, unilateral post-normal occlusion of a difference of 1 mm. or more occurred more frequently on the right side than the left.
   (*N.B.*—Both tendencies were observed in both sets of cases.)

B

3. *Non-significant but possibly relevant results* (difference below 1·5 times Standard Error):
   e. In the 125 Coventry practice cases, unilateral linguo-occlusion of one or more upper incisors occurred more frequently on the left side than the right.
   (*N.B.*—This tendency was not observed in the same degree in Birmingham; though there were many more cases.)
   f. In 59 cases of asymmetry from the group of 200, caries at time of examination was a little more frequent on the right side than the left.
   (*N.B.*—This tendency was observed in all the sub-groups.)

(D.M.F. and recurrent caries figures, where available, tended to follow the same pattern in general.)

All these can be regarded as significant, if account is taken of the consistency of the sub-groups. Since the post-normal cases were unmutilated, the mean displacement of the lower centre-line to the right can be linked with the higher incidence of post-normal occlusion on the right. It was interesting to find this confirmed by our Secretary, Mr. Leighton, who kindly sent me details of 204 children in London, aged 3½ years. He found 25 cases of unilateral post-normal occlusion, of which 20 were on the right, and only 5 on the left (Leighton, 1960).

The higher incidence of linguo-occlusion of cheek teeth on the left side agrees with Rix's findings. As will be seen in *Table III B*, which shows the less conclusive results, I found the same tendency in the upper incisor region in Coventry.

In Birmingham, however, it was not present in the same degree; but there were many more cases of this type. I formed the opinion that the different system of referring patients in Birmingham might have led to the inclusion of a larger proportion of cases due to local causes, which in Coventry might have been filtered off by the referring practitioners. These may have overlaid and concealed the smaller number due to more deep-seated causes.

Although the differences were not great enough to be significant, the initial caries incidence, in the asymmetrical cases, fitted into a pattern consistent with the view that the tongue might have a rather greater scouring action on the left side. This pattern was followed in all the sub-groups. An exception was found in the D.M.F. and recurrent caries figures for one of the sub-groups comprising linguo-occlusion of upper cheek teeth, but only in the lower arch. This may actually strengthen the interpretation, as in these cases one might expect the tongue to be less closely applied to the lower cheek teeth on the affected side, through mechanical obstruction by the inset upper arch.

OTHER ASYMMETRIES REPORTED

We have now reached the point where a latent tendency to asymmetry has been revealed, confirmed in a number of different

places and by more than one observer. The mental picture I have is of an upper arch which tends to be slightly flattened or compressed on the left side, and a lower arch which is more often slewed or deviated to the right. This might be an effort to accommodate itself to the asymmetrical upper arch, in which case the attempt periodically fails, leading to a cross-bite; or it may arise independently.

There is scattered throughout the literature a series of observations which point in the same direction. Friel (1958) found the upper first permanent molar significantly more rotated on the left side than on the right. Lysell (1955) reported a marked difference in the angle of the palatal rugæ on the two sides. Most important for our purposes, Lundström (1951) found two asymmetries in the maxilla, which he regarded as connected. In an unselected sample of 139 boys aged 13, he found a higher frequency of crowding on the left side, and a more forward positioning of the upper first permanent molar on the left side; the upper centre-line being relatively constant. In both cases the difference was significant, and of the same order of size.

This might be explained by a differential frequency in the loss of deciduous teeth on the two sides; but the work of Halikis already quoted, and I hope my own observations, would discount this argument. In a personal communication (1960) Professor Lundström says that in a material of 118 cases, which partly overlapped the series referred to, he could find no significant difference in the incidence of early extractions on the two sides. There were in fact slightly *fewer* upper extractions on the left side (53 against 57). We may therefore eliminate premature extractions as an explanation, and accept the asymmetry as a basic tendency, present before any extractions.

In *Fig.* 18 I have shown the change in the pattern of left–right space loss that results if Lundström's correction is applied. His figure for the average increase in crowding on the left side was 0·45 mm.; and this has been applied as a negative correction in cases of primary extractions in the upper left quadrant. It does not apply in reverse as, when extractions were on the right side, the control measurements were made directly on to the teeth, and would not be affected. In short, in any future work on these lines, one must assume that the upper left quadrant starts

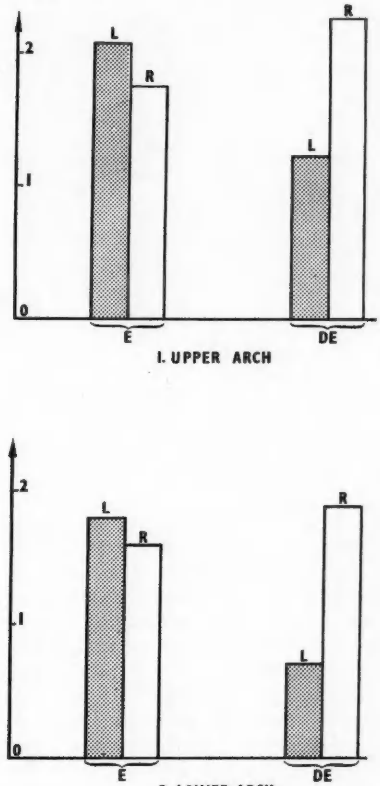

Fig. 18.—Differences between left and right sides, after applying Lundström's correction, using 1960 figures only. Mean rate of space loss in mm. per year.

with an average "handicap" of 0·45 mm.; perhaps this is a potential bias, which shows itself when arch pressures are released by loss of a deciduous molar. At any rate, it must be taken into account.

The effect of the correction is to lower the mean rate of space loss due to the extraction itself. The 2 "left" columns in the upper arch are depressed, leaving the other 6 columns

unchanged. It will be noticed that the patterns of upper and lower arches now resemble each other more closely. There is now little difference between left and right sides in the case of single extractions; but in the case of double extractions, when new forces come into play, the difference in favour of the left side is marked. The difference in the upper DE group is still less than in the corresponding lower group, but it now just comes within the range of sub-significance.

This to me represents the heart of the matter. When all known influences have been allowed for, we are left, I hope, with a clear picture of an asymmetrical field within which a checking force, presumed to be the tongue, can operate under suitable conditions. As might be expected from its anatomical position, this differential checking action by the tongue is more clearly manifested in the lower arch. My explanation may not be correct; but it provides a framework into which all the observed facts can be fitted, and I therefore suggest that it should stand, pending a better one.

POSSIBLE REASONS FOR ASYMMETRY

It would not be right to conclude without some speculation as to the reasons for the asymmetries which appear to be normally present.

Lundström could offer no explanation, but postulated environmental factors, as yet unknown. One which might occur to us is early thumb-sucking; but Leech (1958), Lundström (1958), and others discount its permanent effect, and in more than half of Leighton's cases of unilateral post-normal occlusion, digit-sucking could not be the explanation. Leighton himself says (1953): "One is tempted to believe that these habits only maintain a relationship of the dental arches that was present very early in life, if not at birth." This I believe to be very near the truth (*Fig.* 19).

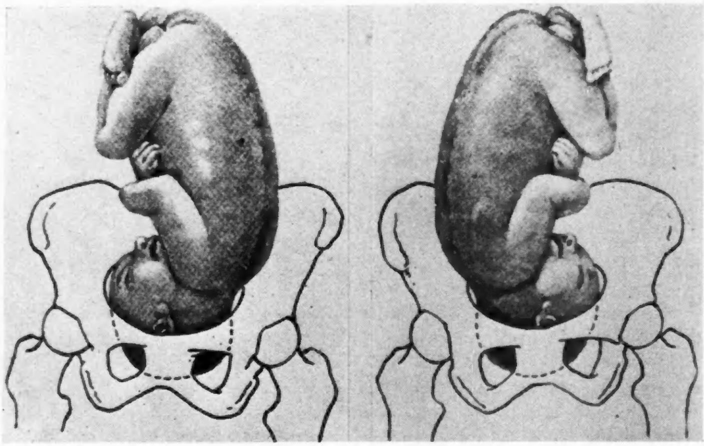

Fig. 19.—Commonest types of birth presentation. Vertex presentation, A, First position (L.O.A.); B, Second position (R.O.A.). (*From Eden and Holland's "Manual of Obstetrics", by courtesy of Messrs. J. & A. Churchill.*)

Vertex presentations constitute the great majority of all labours, and the two commonest types are shown here. The first position (left occiput anterior) occurs in 53 per cent of vertex presentations, and the second position (right occiput anterior) in 21 per cent. The first position is thus more than twice as common as the second. The importance of this is not in the birth itself, but in the fact that this position is taken up some 6 to 8 weeks before birth, according to my medical colleague Dr. D. R. Patchett, to whom I am indebted for advice on this (1960).

Dr. Patchett points out that the uterus is presumably moulded to the bony cavity in which it lies, and that the mother's spinal column presents a marked bony prominence in the posterior wall of this cavity. In the illustrations, it must be imagined as out of sight behind the fœtus, which is here seen from the front. In the first, or commonest, position, the left cheek of the fœtus is in juxtaposition to the sacro-lumbar prominence, and the possibility of a limiting pressure, once a certain stage in development had been reached, can be conceived. In the second position, any such pressure would be on the right cheek. The possibility of some such influence at a late stage of fœtal life appears to be conceded by various authorities, including Drew-Smythe, quoted by Trevor Johnson (1947), and Hamilton, Boyd, and Mossman (1945).

This view, however, does not depend on mere conjecture. In a very interesting report published in 1949, Miss Clinch correlated the type of birth presentation with flattening of the maxillary arch at ages from 1½ to 5 years. In 38 first-position cases, she observed flattening on the left side in 9 cases, but on the right side in only 1. In 28 second-position cases, flattening was seen on the *right* side in 5 cases, but on the left in only 2. Ignoring the cases which were apparently unaffected, the correlation appears to be very strong, though not quite perfect.

This is by no means the whole story. There is in Miss Clinch's series an unexplained residuum of cases with a bias towards flattening on the left side, and it would be wise to admit that we know very little about pre-natal and early post-natal influences. Gesell (1941) attaches great importance to the "tonic neck reflex", which, he states, "dominates the waking life of the infant for some twelve weeks". This may create intrinsic muscular pressures operating more on one side than the other. He was able to trace this reflex as far back as the 28th week after conception. In both pre-natal and post-natal subjects, a strong preference for a right-handed type of behaviour was noted (Gesell and Ames, 1947). It may be that the final birth position is itself brought about by a right- or left-handed pattern of behaviour during the earlier period of free movement, chance sometimes causing a right-handed baby to settle into a left-handed birth position, or vice versa; this might account for some anomalies.

Finally, the apparent swing of the mandible to the right may be initiated in the first 2 weeks after birth, most of which is spent sleeping on the right side. This is the position of greatest comfort, especially after a feed, since it takes weight off the heart; and for this reason newborn babies are normally laid on the right side by the nurse. After watching a number of babies of up to 2 weeks old, I felt that gravitational action of the tongue might perhaps play an appreciable part during that period.

There is, of course, no end to the possibilities of speculation; but I hope I may have opened up a new field of interest and further study for members of this Society.

SUMMARY AND CLINICAL COMMENTS

Using the method of cross-sectional study prior to the eruption of premolars, it has been shown that the mean rate of space loss, when two adjacent deciduous molars are extracted simultaneously, is significantly less than might be expected from a consideration of the effect of extracting the constituent teeth singly. There is in fact no evidence that the ill-effects are usually any greater than when one second deciduous molar is extracted alone. Certain associations with tongue behaviour and cuspal lock have been pointed out, and the most favourable results were observed in the lower arch. The checking effect was found to operate more efficiently on the subject's non-dominant side (usually the left), and the explanation of this is thought to be the presence of a tendency towards skeletal asymmetry, which is to be regarded as normal for the human race.

The precise clinical applications will depend on how far the conclusions reached can be generally accepted. For those who feel that a coherent pattern has emerged, the implication would seem to be that the second deciduous molar should be regarded as the key tooth in

the deciduous and early mixed dentition. Once this tooth is condemned, it would appear to be advantageous, in most cases, to remove the adjacent first deciduous molar as well, so as to allow natural space-maintaining forces more play. This policy can be followed with more confidence when the extractions are in the lower arch, and results will often be better on the left side (in right-handed patients). It would perhaps be wise not to go further than that at present; but a study of local conditions in each case may influence prognosis.

Two points must be emphasized. Unplanned extractions are still to be deplored; and our present knowledge is so limited, in relation to the high variability in response, that it is still necessary to follow through each case individually to determine whether a space retainer may become necessary. It is hoped that further study of the material will throw more light on the associated aspects in due course.

Acknowledgements.—Amongst many colleagues who have shown interest, I would like especially to thank Messrs. Rix and Pringle for help and encouragement; Mr. Leighton and Miss Clinch for making valuable material available to me; Professor Lundström of Sweden, Professor Braccesi of Italy, Dr. Froeschels of the U.S.A., and Dr. Patchett of this country, for information and advice; the Librarian of the Royal College of Surgeons, who has spared no effort to trace dextrality references from many quarters for me; and Dr. Boyd of the London School of Hygiene and Tropical Medicine, who has kindly discussed my statistics. I am grateful to Mr. J. A. Smith, Principal School Dental Officer for Coventry, and to the Coventry Local Authority, for facilities for the main study; to Mr. D. Glen Thomson, Principal School Dental Officer for Birmingham, for permission to use the Birmingham material; and to the Coventry and Warwickshire Hospital, for access to their Maternity Unit. In thanking all these people, I hasten to add that none of them is to be held responsible for the opinions expressed, which are entirely my own.

I would also like to thank Messrs. J. & A. Churchill for permission to show the illustrations of birth presentations, and Mr. Richard Bailey of Coventry for the photographs and slides.

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STATISTICAL APPENDIX

The principal figures referred to in the text are given below:—

1. Mean Rate of Space Loss (*Fig.* 6).

Upper arch: D group (1951): 0·83 mm. per year
E group (1951): 2·24 mm. per year
E group (1960): 2·03 mm. per year
DE group (1960): 2·02 mm. per year (corrected to 1·95)

Lower arch: D group (1951): 0·91 mm. per year
E group (1951): 1·68 mm. per year
E group (1960): 1·69 mm. per year
DE group (1960): 1·27 mm. per year

Number in each group (1960 only)
Upper E group: 24 — Upper DE group: 26
Lower E group: 27 — Lower DE group: 25

Standard Deviation in each group (1960 only)
Upper E group: 0·97 mm. per year
Upper DE group: 1·61 mm. per year
Lower E group: 1·11 mm. per year
Lower DE group: 1·32 mm. per year
(to obtain Standard *Error*, these values should be divided by 5 approximately)

2. Clinical Observations (*Table II*).—

a. Frequency of "good" and "poor" cuspal locks (excluding doubtful cases)
Upper E group: "Good", 3; "Poor", 20; Total 23
Upper DE group: "Good", 6; "Poor", 19; Total 25
Lower E group: "Good", 11; "Poor", 16; Total 27
Lower DE group: "Good", 13; "Poor", 12; Total 25

b. Frequency of "tongue bulge" (*active or passive*) (excluding doubtful cases)
Upper E group: observed in 10 out of 20 cases (50 per cent)
Upper DE group: observed in 17 out of 20 cases (85 per cent)
Lower E group: observed in 16 out of 25 cases (64 per cent)
Lower DE group: observed in 17 out of 21 cases (81 per cent)

c. Frequency of "diversion" of tongue bulge (actual or potential) (i.e., frequency of additional extractions in *opposing* quadrant)
Upper E group: recorded in 18 cases out of 24
Upper DE group: recorded in 13 cases out of 26
31/50 (62 per cent)
Lower E group: recorded in 8 cases out of 27
Lower DE group: recorded in 5 cases out of 25
13/52 (25 per cent)

d. Comparison of cases with and without tongue bulge (lower E group)
With bulge: 16 cases. Mean rate of space loss: 1·35 mm. per year
Without bulge: 9 cases. Mean rate of space loss: 2·27 mm. per year
Standard Deviation: with bulge: 0·70 mm. per year ($\div 4$ to give S.E.)
Standard Deviation: without bulge: 1·45 mm. per year ($\div 3$ to give S.E.)

e. Comparison of cases with "good" and "poor" cuspal lock (lower DE group)
Good lock cases: Mean rate of space loss: 0·91 mm. per year (13 cases)
Poor lock cases: Mean rate of space loss: 1·60 mm. per year (12 cases)
Standard Deviation: good lock cases: 1·97 mm. per year
Standard Deviation: poor lock cases: 1·55 mm. per year

f. Influence of Diversion of Tongue Bulge (upper DE group)
Mean rate of space loss for diverted cases: 2·25 mm. per year
Mean rate of space loss for non-diverted cases: 1·79 mm. per year

g. Influence of type of swallowing behaviour (as observed by palpation of masseter muscle) (lower DE group cases *with* tongue bulge)
Mean rate of space loss with teeth-together swallow: 0·46 mm. per year
Mean rate of space loss with teeth-apart swallow: 1·29 mm. per year
Standard Deviation: T.T. swallow: 0·84 mm. per year (8 cases)
Standard Deviation: T./A. swallow: 1·61 mm. per year (9 cases)

3. Asymmetries (*Table III*).—

a. Displacement of dental centre-line. Of the 102 research cases, the lower dental centre-line was displaced (relatively to the upper) as follows: to the left, in 31 cases; to the right, in 46 cases; the remaining 25 cases having no displacement. Additional extractions were symmetrically disposed. (Mean displacement 0·35 mm. to right.)

b. Unilateral linguo-occlusion of upper cheek-teeth:
Coventry: Number examined: 125. L-O on left: 5 cases. On right: 2 cases
Birmingham: Number examined: 75. L-O on left: 2 cases. On right: 0 cases

c. Unilateral post-normal occlusion (substantially unmutilated cases):
Coventry: Number examined: 125. P.N.O. on left: 4 cases. On right: 9 cases
Birmingham: Number examined: 75. P.N.O. on left: 1 case. On right: 3 cases

d. Unilateral linguo-occlusion of upper incisors:

Coventry:	Number examined: 125.	L-O on left: 10 cases.	On right: 5 cases
Birmingham:	Number examined: 75.	L-O on left: 13 cases.	On right: 12 cases

e. Cavities at time of examination (asymmetrical cases only):

Coventry:	"cheek-teeth" group:	11 on left side.	18 on right side
Birmingham:	"cheek-teeth" group:	2 on left side.	3 on right side
Coventry:	"post-normal" group:	15 on left side.	18 on right side
Birmingham:	"post-normal" group:	2 on left side.	6 on right side
Coventry:	"incisor" group:	22 on left side.	23 on right side
Birmingham:	"incisor" group:	21 on left side.	24 on right side

4. Differences between Left and Right Sides (Amended) (*Fig.* 18).—

Group	*Side*	*No. of cases**	*Mean rate of space loss*	*Standard Deviation*
Upper E	Left	13	2·07 mm. per year	0·86 mm. per year
Upper E	Right	11	1·75 mm. per year	1·03 mm. per year
Upper DE	Left	10	1·23 mm. per year	1·82 mm. per year
Upper DE	Right	16	2·26 mm. per year	1·42 mm. per year
Lower E	Left	14	1·79 mm. per year	1·20 mm. per year
Lower E	Right	13	1·59 mm. per year	0·98 mm. per year
Lower DE	Left	13	0·70 mm. per year	1·55 mm. per year
Lower DE	Right	12	1·89 mm. per year	1·88 mm. per year

* After correction for "social" left-handedness.

DISCUSSION

The President congratulated Mr. Breakspear on doing a research of that size while he was mainly engaged in private practice. It was quite amazing. He hoped that it might stimulate one or two other members who were in private practice to produce some form of research.

The President then called on Mr. A. C. Campbell to open the discussion.

Mr. Campbell said: I would like to thank Mr. Breakspear for his paper, for bringing to our notice the results of much painstaking effort, and also for delving into regions far removed from our field of activities to seek explanations for some of his findings.

He has given us evidence to show that there is no greater rate of space loss when two adjacent deciduous molars are extracted simultaneously, than when a second deciduous molar alone is removed. Over the whole series of cases, however, the difference in rate of space loss is not statistically significant. When he analyses the rates for left and right sides, however, differences are shown which come within the range of statistical consideration, and may possibly be considered significant. From a clinical point of view, of course, as Mr. Breakspear suggests, we must consider each case individually both in advising extractions, and possibly in advising space maintainers, but I think that we shall want to consider the whole matter most carefully before advising the removal of a sound lower left first deciduous molar in a right-handed child, at the same time as a second deciduous molar, which has to be removed because of caries.

Mr. Breakspear has described various "checking" factors which would tend to reduce the rate of space loss, but I wonder if he was able to note any correlation with general physique and vitality. For want of a better term —Was the rate of space loss in any way allied to good or poor growth potentials? In this connexion, I think it would be of value to know something of the skeletal form, and also the soft-tissue morphology and behaviour. For example, we all recognize the Skeletal III type of case which frequently exhibits spacing in the lower arch. In such a case one would not expect to see space loss following premature extractions in the lower arch. Similarly, we recognize that the soft tissues influence the centrifugal development of the dental arches, so that at one extreme we find splaying out and spacing of the teeth, whilst at the other extreme we find crowding. We would not expect to see the same types of space loss in these two types of case.

It seems to me that there may be some additional factor at work to help explain the small rate of space loss when two adjacent deciduous molars are extracted. It has been suggested by Ballard, I think, that the lingual collapse of lower incisors is materially the same no matter which cheek teeth are extracted, so that the loss of one or two teeth should make little difference here. However, as Mr. Breakspear suggests, where two teeth have been removed it is easier for the tongue to insinuate itself into the gap and so have a better chance of holding back the first permanent molar. In the upper arch, however, he has shown the rate of space loss to be greater, and suggests that the tongue does not so readily occupy this space to hold back the first permanent molar. Is it not possible that the difference between upper and lower arches is related to the different paths of eruption which the upper and lower molars follow? We have all seen how, when they are "stacked up", the upper molars tend to move downwards and forwards with great rapidity whenever they are given the opportunity.

As far as the left–right differences are concerned, the theory of skeletal asymmetry has much to support it, and one appreciates that facial symmetry is rare. For example, it is well known that if one lateral half of a full-face photograph is mirrored to produce a symmetrical full-face photograph, the "faked" picture may well be unrecognizable when compared with the original subject. However, I feel a little doubtful about accepting the suggested causation. We would agree that, although a persistent sucking habit may produce derangements of occlusion, these will not persist when the habit is given up unless there is some other abnormality present which fosters them. I think also that we would agree that the pressures exerted are unlikely to affect either the amount or direction of skeletal growth. Similarly, I find it difficult to accept that the transient, although powerful, pressures exerted on the fœtus before, during, and after birth

can have any long-lasting effects unless there has been gross trauma. I think that it would be interesting to know something of the genetic background of the individuals showing the asymmetries, for there are many variations of the skeletal pattern which we are prepared to accept as genetically determined—Why not asymmetries also?

It is difficult, of course, to know which is the chicken and which is the egg, but a more persistent locally acting factor might be the mechanism of mastication for the particular individual. Many people have a "favourite" chewing side, and of course in adult life in particular there may be many factors contributing to this, but Eschler did suggest from his electromyographic recordings in infants that action potentials were not bilaterally asymmetrical. It is possible that this asymmetry may persist with moulding effects upon the teeth and their supporting structures.

In conclusion I would like to thank Mr. Breakspear for letting me see the draft of his paper beforehand, and I would congratulate him on its production, for I know how much time from his practice it must have demanded of him.

Mr. B. C. Leighton said that he had noticed, during the course of his own researches on infants at birth, that the incidence of asymmetry at birth was not uncommon and was sometimes quite extreme. Examination of the infants subsequently showed, in the majority of cases, that that asymmetry disappeared, but that was perhaps supported by the observations of Brodie on asymmetry of the cranium at birth. Brodie noticed in some infants that the cranium was so compressed during birth that there was overlapping of the parietal and frontal bones and that that disappeared within the first six weeks after birth.

He was inclined to agree with Mr. Campbell that the influence of birth itself and pre-natal posture was probably rather a doubtful aetiological factor. He confirmed that he noticed repeatedly that post-normality occurred more frequently on the right side than the left where it was one-sided post-normality.

Did Mr. Breakspear differentiate between closure of space from the front of the mouth from closure of space by forward movement of molars? These seemed to be rather important aspects of it, that space could be closed by collapse of the incisor segment or by forward movement of the molars.

Miss L. M. Clinch said Mr. Campbell had queried mastication and that was a point which Mr. Breakspear had not mentioned. That might have a bearing on many of the effects after early loss of teeth; more mastication on one side would result in more attrition on that side which would interfere with the cuspal lock which must be a very big factor in retaining space.

The centre line which Mr. Breakspear had mentioned as having become displaced at 8 years of age very often corrected itself at a later stage. It was, quite often, only a temporary displacement. There was a point which Mr. Leighton had made which she also wanted to ask Mr. Breakspear about. In the lower arch one very often, after loss of teeth, got a lack of growth anterior to the extraction, whereas in the upper arch, one got a mesial drift of the teeth posterior to the extraction. It did not always work that way, but there was a difference in the two arches in the way the loss of space arose. Could Mr. Breakspear clear that point up?

Mr. D. T. Hartley said that Mr. Breakspear had explained that, with a normal distribution curve, any figure which differed from the mean by more than twice the standard deviation had only a one-in-twenty likelihood of occurring by pure chance. Could he say the corresponding proportion for a figure which differed from the mean by only 1·5 times the standard deviation, so that the significant results could be evaluated?

Mr. J. S. Beresford thanked Mr. Breakspear for his very interesting paper. When he completed the hat trick and gave his third paper, Mr. Beresford hoped Mr. Breakspear would be able to include a statistical discourse on the relevance of the degree of disproportion between the tooth size and bone size, and the age at which the deciduous tooth was extracted.

On nothing more than clinical observation, one felt that the amount of space that the teeth wanted had a lot to do with it, and the age at which the loss occurred. He was not quite sure why Mr. Breakspear had rejected the 1951 figures. If the 1951 figures and the 1960 figures were put together, there was virtually no difference between left and right side. He thought one should be careful not to construct too big an edifice on slender foundations.

Mr. Russell asked if Mr. Breakspear had any comment to make on the question of cuspal lock and Angles classification. There was some slight significance on the question of the dexterity of dental surgeons in general and their preference of treatment of sides. A lot of dental surgeons did not like working on one side or the other, especially in difficult cases, such as children. He did not know whether that had any bearing at all.

Mr. Allen asked whether Mr. Breakspear would recommend having two lower teeth extracted in a case in which he would expect the tongue to bulge in and occupy the space where the loss of one was certain.

Another speaker said that, in connexion with asymmetry, he had noticed that in cases where the arches were very short and there was impaction of the upper first molar by the upper second temporary molar, the condition was usually not symmetrical. One would find one case where a molar was so far forward that the "E" was loose—so loose that one could almost take it out, or it came out. In other cases, the impaction was very much less so one undertook extraction oneself, which was obviously necessary. He was afraid he had not noticed whether the right side was more forward than the left or the other way round. Had Mr. Breakspear ever noticed that?

Mr. Breakspear, in reply, said that he hoped further study would be forthcoming. He had thrown out a few ideas and had not been so heavily "sat on" as he thought he was going to be.

In answer to Mr. Campbell, it was quite right to stress the need for caution in interpretation of results. Even a difference which was significant might occur by chance; on the other hand, they knew that, in most of their working life, they had to make decisions clinically without all the evidence they would like to have in theory, and had to use their judgement sometimes: and if a thing seemed to tie up with other things and make sense, they would naturally, as clinicians, have a bias in its favour. The statisticians might think that was a wrong bias; but the universe did make sense, and things which appeared to make sense to him had a strong argument, in his mind, for acceptance pending further evidence.

There was a negative aspect of it, as he had tried to point out. Although the difference between the single

and double groups was not significant, it was always in one direction. There was no evidence that the extraction of two teeth produced a higher rate of space loss. There was a small amount of non-significant evidence in the other direction.

The other questions raised would help to explain variability. There was a big variability in the response of people to those extractions within each individual group, and he had not dealt with that at all in the study; but there was a vast mass of material which he was hoping in due course to analyse, and he hoped to have the answers later on. He would prefer not to comment on them. He had clinical notes on all those things—skeletal form, etc. It took a long time to work them out, and also to be quite sure that one was comparing two things which were comparable. One of the difficulties was that one might compare two groups where there was a common factor which overlapped another one, and consequently think that one factor was the explanation, when it was due to something else. That was found over cuspal lock and tongue bulging. It was not easy to find sub-groups which were comparable; but, if all went well, he hoped that later on he could produce something on those lines.

With regard to paths of eruption, he agreed that by its nature the upper molar appeared to be more difficult to check than the lower, which might partially explain the results.

He had been careful to say that thumb-sucking was not a primary cause and other things might be. Not much was known about it; but it was known that foundations once laid down were not easily altered, and he would not like to say offhand that those pre-natal influences could all be written off as purely temporary. It might be so, but it might not be so; and Miss Clinch's figures which he had shown, correlated with the type of birth presentation, pointed strongly to the fact that there was some connexion. More than that, one could not say.

With regard to chewing, people did have a favourite side for chewing—the side where teeth were present was more favoured anyway. He had no material on that, but he might, by inference, be able to produce an answer to that question later.

He had been careful to suggest that it was not the birth itself which caused asymmetry but the formative period before birth, going back for a month or more, which was a different thing altogether. Most of the birth asymmetries seemed to occur in the top of the skull rather than down in the facial regions. That was quite a different thing.

Direction of space closure was important and he hoped to throw more light on that in due course.

To Miss Clinch, he said he agreed that attrition might weaken cuspal lock on one side more than the other. He also agreed that centre-lines varied a great deal; he had just taken a cross-section of them as they were at the time, and some reason would have to be found why the centre-line was deviated to one side at that age. It might be that at the age of 12 it was deviated differently, but some explanation was wanted. Miss Clinch's method of longitudinal study did have advantages; each method produced different information and this had to be put together. The question of upper and lower arches was something which he hoped to be able to work out in more detail later on.

To Mr. Hartley, the answer was 0·2—or one-in-five.

With regard to Mr. Beresford he hesitated to commit himself about age of extraction. There was a tendency for cases with very early extraction to be a little more rapid in their space loss than the older ones; the proportion was about six to seven. What *was* important was the time which elapsed. If a tooth was extracted at the age of four, it had six years for space to be lost; if it was extracted at nine, perhaps only one year. That had to be taken into account.

The 1951 figures had not been rejected; they had been qualified. In 1951, he had assumed a "blanket" encroachment of 1 mm. average for every case. That had not fitted in with other things that were known, and it had appeared to him that the encroachment factor was subject to an age variation, by which teeth extracted early had (on average) lost less interstitial substance than those extracted later. He had therefore worked out for each one a theoretical amount of encroachment, which made the new figures more precise.

He did not agree that there was no difference between left and right sides in the double group. That was so in the single group; he had tried to explain that. In the double group there was quite a big difference between left and right sides.

With regard to preference of treatment by dental surgeons, that was an interesting point and one which was new to him. He would have to think about it.

Most of the other points mentioned had been covered by his general plea for time to take note of the questions, and to see what he could do about producing answers some time in the future.

Otalgia caused by a Broken Needle in the Pterygomandibular Space

A 22-year-old sailor in the U.S. Navy complained of pain and deafness involving the right ear, although no local disease could be demonstrated. Examination of his mouth revealed two recent extraction wounds and a partially erupted third molar. Radiographs of the alveolar processes showed only the sockets and several teeth with incipient caries, but oblique lateral and postero-anterior views of the jaw showed a broken needle in the right pterygomandibular region. The patient then remembered that a needle had been broken 5 years previously.

The needle was therefore removed under local anæsthesia. It was tarnished, but otherwise not corroded. The post-operative course was uneventful, and 2 weeks later the patient was entirely free from symptoms. His pain was probably a referred pain from the inferior dental nerve, felt in the auriculotemporal region.—Wigand, F. T. (1960), *J. oral Surg.*, **18**, 439.

G. R. Seward